United States Patent [19]

Kaufman

[11] **Patent Number: 5,016,514**

[45] **Date of Patent: May 21, 1991**

[54] **CAPO FOR STRINGED INSTRUMENTS**

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[21] Appl. No.: **562,827**

[22] Filed: **Aug. 6, 1990**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 492,483, Mar. 12, 1990, abandoned.

[51] **Int. Cl.**[5] **G10D 3/04**

[52] **U.S. Cl.** **84/318**

[58] **Field of Search** 84/318

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Attorney, Agent, or Firm—Baker, Maxham, Jester & Meador

[57] **ABSTRACT**

A capo for detachably mounting on the neck of a fretted stringed musical instrument for selectively raising the pitch of the instrument comprises an elongated spring bar having a length for extending across and engaging the strings on the neck of an instrument, an elongated elastic tension member connected to opposite ends of the spring bar and extending across the back of the neck of the instrument for pulling the strings into engagement with the frets of the instrument, and an elongated elastic cover for extending over and covering the spring bar and for extending over and covering the elastic tension member.

18 Claims, 2 Drawing Sheets

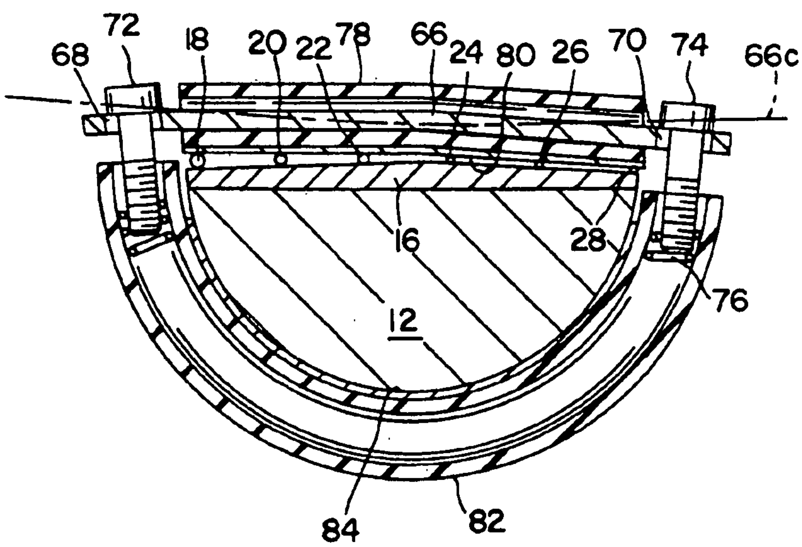


FIG. 1

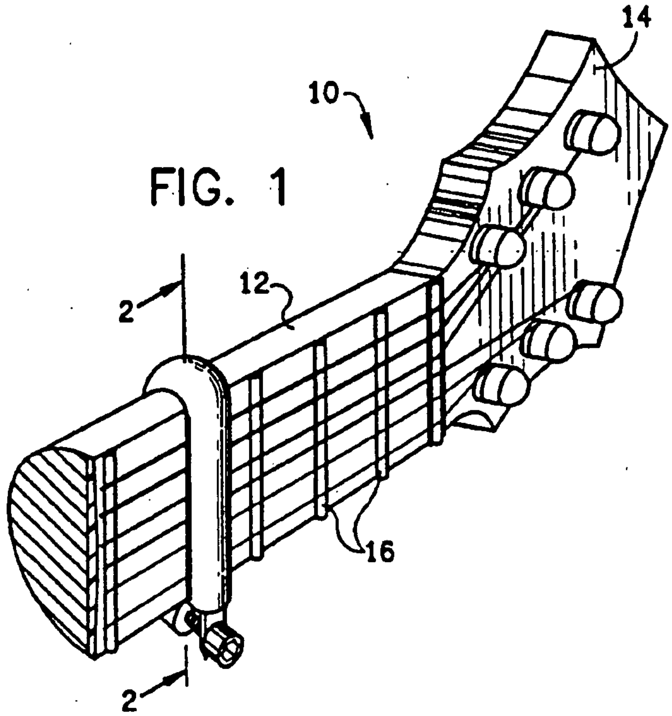
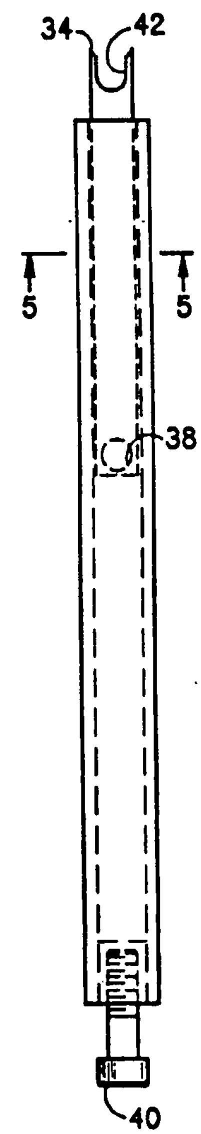


FIG. 3



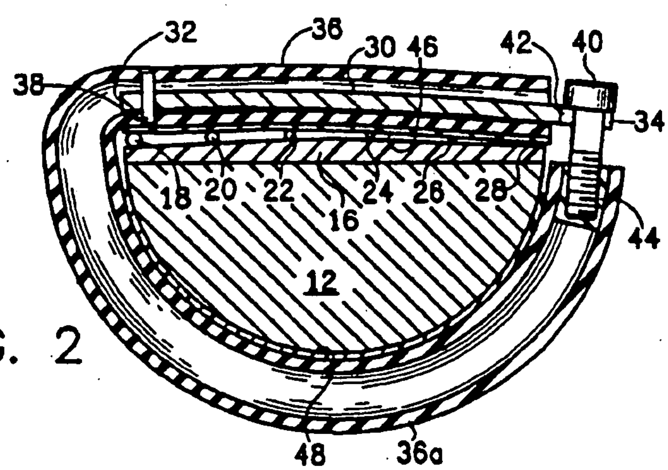


FIG. 2

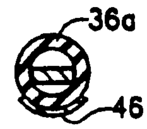
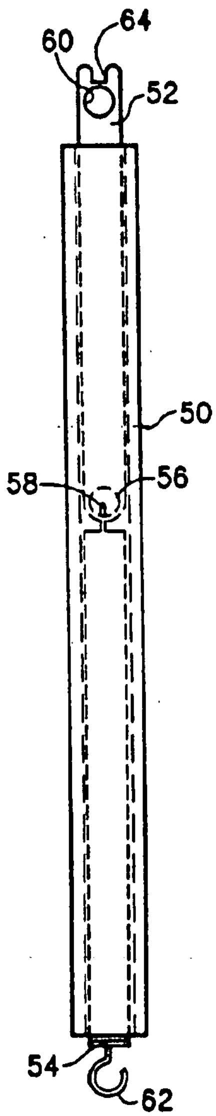


FIG. 5

FIG. 4



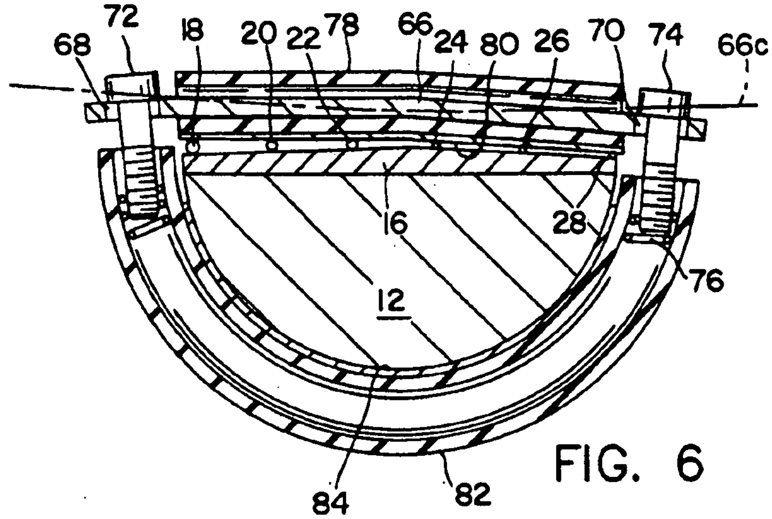


FIG. 6

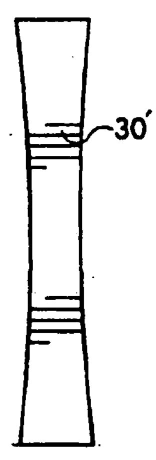


FIG. 7

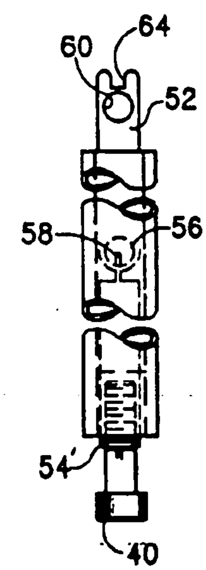


FIG. 8

CAPO FOR STRINGED INSTRUMENTS

REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of my co-pending application Ser. No. 07/492,483, filed Mar. 12, 1990, now abandoned, entitled "Capo For Stringed Instruments".

BACKGROUND OF THE INVENTION

The present invention relates to attachments for stringed instruments and pertains particularly to an improved capo for fretted stringed instruments.

It is frequently desirable to raise the pitch of the strings of fretted stringed musical instruments. This is typically accomplished by means of a device called a capotasto, usually referred to as a capo. A capo is typically a device which is clamped across the strings for pulling and clamping the strings to the frets which are embedded in the finger board or neck of the instruments. This shortens the effective vibrating length of the strings, and thereby raises the pitch thereof.

The prior art capos typically employ a straight rigid bar for extending across the strings, with a strap extending behind the neck of the instrument for securing the bar in place. The bar is moved to various fret locations along the finger board for selectively raising the pitch of the instrument. Relatively large forces are required to simultaneously clamp all strings with a straight rigid bar due to the adverse profile imposed by the tops of the strings. Several devices have been devised to increase the clamping force to effectively clamp the strings to the frets. These, however, tend to be unwieldy and unreliable, and require unusual manual dexterity to use. These prior art devices must be removed or loosened to change position along the finger board and then retightened. When not in use, they are typically removed from the instrument and temporarily stored.

In my prior application, I disclose an improved capo having a spring bar that deflected and progressively applied pressure to the strings to bias them into engagement with the frets. The bar included variations in the cross sectional configuration to vary the stiffness of the bar along the length thereof. The application also disclosed improved sheaths for the capo. I have discovered further improvements in bar configuration and sheaths that are incorporated herein.

It is desirable that the capo be capable of biasing all of the strings uniformly into engagement with the frets, and be simple and easy to move to selective locations along the neck of the instrument.

SUMMARY AND OBJECTS OF THE INVENTION

It is the primary object of the present invention to provide an improved capo for fretted stringed instruments.

In accordance with a primary aspect of the present invention, a capo for raising the pitch of a fretted stringed musical instrument comprises an elongated spring bar for extending across the strings of an instrument, an elongated elastic sheath combination having a section with a length for extending over the bar and a second section for encircling the neck of the stringed instrument, and elongated elastic means connected to opposite ends of the spring bar and extending across the back of the neck of the instrument for pulling the spring bar into engagement with the strings, and the strings into and against the frets of the instrument.

BRIEF DESCRIPTION OF THE DRAWING

The above and other objects and advantages of the present invention will become apparent from the following description when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a perspective view illustrating a preferred embodiment of the invention in use;

FIG. 2 is a section view through a neck of a stringed instrument;

FIG. 3 is a top plan view illustrating the embodiment of FIG. 1;

FIG. 4 is a top plan view of an alternate embodiment of the invention;

FIG. 5 is a section view taken on line 5—5 of FIG. 3;

FIG. 6 is a view like FIG. 2 illustrating another embodiment of the invention;

FIG. 7 is a top plan view of an alternate embodiment of the spring bar; and

FIG. 8 is a top plan view of a still further embodiment of the invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings, and particularly to FIG. 1, there is illustrated an exemplary embodiment of a capo in accordance with the invention shown in use on the neck of a typical stringed instrument, designated generally by the numeral 10. As illustrated in FIG. 1, a neck 12 of an instrument has a head 14, with a finger board formed by a generally flat surface of the neck having a plurality of frets 16 mounted thereon in spaced relation in a conventional fashion. The instrument, as illustrated in FIG. 2, illustrates a curved upper surface to the frets 16, with a plurality of spaced apart strings 18, 20, 22, 24, 26 and 28 aligned over and across the frets. The curved fret adds to the difficulty with the use of prior art devices.

Referring to FIGS. 1-3, an exemplary embodiment of a capo in accordance with the invention is illustrated. The capo comprises an elongated flat spring bar having a length sufficient to span the strings of the instrument, with an end 32 connected to an elongated elastic member, which will be described, which extends around the neck of the instrument and connects to another end 34 of the spring bar. The spring bar 30 may be constructed of any suitable material, but is preferably constructed of a spring steel of C 1075 steel. The spring bar, in accordance with a preferred embodiment of the invention, is on the order of approximately 0.050 inches in thickness and approximately 0.25 inches in width. The width can vary, as will be subsequently explained, to provide a varying stiffness along the length of the spring bar for accommodating certain curvature conditions at different fret positions, and distributing force uniformly to or across the strings, as will be explained.

The spring bar member may be constructed of other suitable materials, but preferably has a stiffness or spring rate to apply approximately eight to twelve pounds of force to the strings, and to conform by such force to any curvature of the finger board while applying force uniformly to each string. The overall unit is constructed such that the force applied may vary from approximately eight pounds at the first fret up to about twelve pounds at the sixth fret. It will be appreciated that the neck of most instruments vary in cross sectional config-

uration between the head and body of the instrument. The cross section tends to increase from the head toward the body. This variation in cross section varies with various instruments, and the structure of the present capo takes this into consideration.

The spring bar 30 is covered in or mounted within one end of an elongated elastic tube, which in this embodiment serves not only as a covering but also as the elastic member or means for applying the force to the ends of the spring bar. The elongated tubular member has a first portion 36, which extends over and covers the bar 30, with a second portion 36a that extends from the end of the bar around the neck of the instrument to the opposite end of the bar and is connected thereto. The elongated elastic tubular member is preferably connected to end 32 by means of a brad or rivet 38, and is connected to the opposite end of the bar by means of a screw member 40, which extends into a slot 42 in the end of the spring bar 30, and threadably engages a threaded insert 44 within the end of the tubular member 36.

The elongated tubular member 36 may be constructed of any suitable material having the desired durability and elasticity to accommodate the movement of the capo along the neck of the instrument, and to apply forces to the ends of the spring bar 30 of between about eight and twelve pounds. I have found a preferred material to be polyurethane, with a second choice being that of ethylene-propylene. A first low friction surface 46 is provided along the top section of the tube, with a second low friction surfacing 48 provided on the surface that extends around and engages the neck of the instrument, as shown in FIG. 5. This low friction surface or coating is common to all embodiments of the invention. The screw 40 may be selectively adjusted to adjust the tension in the section 36a of the tube.

The low friction surface 46 and 48 may be formed by one continuous strip or a coating or by other means. A suitable form of low friction surfacing is formed by the application of an ultra high molecular weight polyethylene tape thereto. This tape provides a wear resistant surface against the strings, and it also provides a low friction surface against the neck of the instrument to enable it to be easily moved along the neck of the instrument.

It is also possible to provide the low friction surface by incorporating a lubricant into the tubing, such as a moly-disulfide or by a coating of Teflon. A Teflon coating, if used, would be only on that portion of the tube which wraps around the neck of the instrument, since it would not wear well over the strings.

Referring to FIG. 4, an alternate embodiment is illustrated wherein an elongated tubular sheath 50, as in the previous embodiment, extends over a spring bar 52 and also over an elongated spring member in the form of a coil spring 54. In this embodiment, the spring bar 52 is provided at one end, with an eyelet 56 for receiving a hook 58 of an elongated coil tension spring 54. The opposite end of the bar is provided with an eyelet 60 for receiving a hook 62 on the opposite end of the tension spring 54, and with a notch 64 for preventing rotation of the spring 54 as the capo is moved along the neck of the instrument. The coil spring 54 is preferably pre-tensioned to have about three pounds of force that remains substantially constant over a necessary range of stretch. The tubular sheath 50 extends over the spring bar member 52 and over the coiled tension spring member 54. The sheath is provided with low friction surfaces as previously described.

This is a preferred embodiment of the invention where the neck of the instrument varies any significant amount in cross section along the length thereof. This embodiment enables one to obtain a more uniform force on the strings of the instrument, with movement of the capo along the neck of the instrument. This is particularly desirable with a modification, as will be subsequently explained, wherein a spring bar varies in cross section along its length to more easily conform to any curvature of the finger board of the instrument.

Referring to FIG. 6 of the drawing, there is illustrated a still further embodiment, now considered the preferred embodiment of the invention. This embodiment is illustrated like FIG. 2 wherein the same elements are identified by the same numerals, and equivalent or like elements are given their own numerals. As illustrated, an elongated spring bar 66 is provided with bores 68 and 70 at the opposite ends thereof for receiving a pair of tension screws 72 and 74. The ends of the bar 66 are preferably bent downwardly, up to about twenty degrees to provide better alignment of screws 72 with the spring 76. The bar 66 is preferably bent or curved wherein the center is displaced about forty thousandths (0.040") toward the neck from the ends. The bar is curved or concave away from the curvature of the neck of the instrument before tensioning, as shown by centerline 66c. Thus, the center of the bar engages the strings first and is pulled down progressively toward the ends, applying substantially uniform force to the strings.

In this embodiment, the tension or elastic forces applied to the ends of the bar 66 are accomplished by means of the elastic spring member 76 in the form of a coil tension spring, which is selected to apply a force of between eight and twelve pounds to the ends of the bar 66. The spring is attached to the bar by means of a pair of screws 72 and 74 extending through holes 68 and 70 in the ends of the bar, and threadably extending into the ends of the elastic spring member 76. The screws enable the tension in the spring and bar to be adjusted to an extent by extending the screws further into the ends of the spring. The screws (at least one, 74) preferably have knurled heads to enable finger rotation and adjustment thereof. The other screws may be covered by an elastomer cap 82. The bar 66, as illustrated, is biased by the spring 76 to conform to the curvature of a line across the top of the strings.

A sleeve 78 preferably formed of polyurethane fits over and covers the bar and engages the strings. The sleeve may also have a coating or tape 80 of polyurethane or ultra high molecular weight polyethylene, particularly if formed of other materials. An elongated tubular sleeve 82 extends over and covers the spring 76 for engaging and protecting the finish of the neck 12 of the instrument. This sleeve may also be made of another material and have a Teflon or ultra high molecular weight polyethylene tape 84 along the length thereof for engaging the surface of the neck.

Referring to FIG. 7, an alternate embodiment of the spring bar is illustrated wherein the spring bar 30' varies in cross-section along the length thereof to vary the spring force or flexure along the length thereof. As illustrated, the width varies with a uniform thickness. The bar decreases in width from the ends to the center. The bar may also vary in thickness with a uniform width with the same effect. This gives varying flexibil-

ity to the spring bar over its length to enable it to distribute a more uniform force along its length at different fret positions.

Referring to FIG. 8, a modified version of the FIG. 4 embodiment is illustrated. A screw 40 extends through hole 60 in spring bar 52 and into threads in the end of coil spring 54'. This enables an adjustment in the tension of coil spring 54'. This notch 64 in spring bar 52 may be eliminated. The FIG. 4 and FIG. 8 embodiments are preferred, because the tension in springs 54 and 54' remain essentially constant over time. They can also be selected with a pre-set tension which will remain more uniform over time.

While I have illustrated and described my invention by means of specific embodiments, it is to be understood that numerous changes and modifications may be made therein without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. A capo for raising the pitch of a fretted stringed musical instrument having an elongated neck, comprising:
- an elongated spring bar for extending across the strings of an instrument and shaped for uniformly distributing force thereto for progressively biasing all strings into engagement with frets on the neck of the instrument, said elongated spring bar varying in width along the length thereof for varying the spring rate over the length thereof;
- an elongated elastic sheath means having a first portion for extending over said bar and a second portion for encircling the neck of a stringed instrument; and
- elongated elastic means connected to opposite ends of the spring bar and extending across the back of the neck of the instrument for pulling the spring bar into engagement with the strings and the strings into and against the frets of the instrument.

2. A capo according to claim 1 wherein:
- said elongated spring bar is formed to curve away from the neck of the instrument until biased by said elastic means into engagement with the strings of the instrument.

3. A capo according to claim 1 wherein:
- said elongated elastic means comprises a coiled tension spring having first means on one end thereof for connecting to one end of said spring bar, and second means on the other end for connecting to the other end of the spring bar.

4. A capo according to claim 3 wherein:
- said first and said second connecting means comprises a screw threadably extending into the respective ends of said coiled tension spring.

5. A capo according to claim 4 wherein:
- said first portion of said sheath means has a wear resistant surface for engaging said strings and said second portion has a low friction surface for engagement with said instrument neck.

6. A capo according to claim 5 wherein:
- said wear resistant surface is defined by a polyurethane or ultra high molecular weight polyethylene surface and said low friction surface is defined by a Teflon or ultra high molecular weight polyethylene surface of said sheath.

7. A capo according to claim 1 wherein:
- said sheath has a wear resistant surface for engaging said strings and a low friction surface for engagement with said instrument neck.

8. A capo according to claim 7 wherein:
- said wear resistant surface is defined by a polyurethane or ultra high molecular weight polyethylene surface and said low friction surface is defined by a Teflon or ultra high molecular weight polyethylene surface of said sheath.

9. A capo for mounting on the neck of a fretted stringed musical instrument for selectively raising the pitch of the instrument comprising:
- an elongated spring bar having a length for extending across the strings on the neck of an instrument and a curved configuration for uniformly distributing force thereto;
- an elongated elastic means extending from one end of the bar and extending across the back of the neck of the instrument for pulling the bar into the strings and the strings into and against the frets of the instrument, said elongated elastic means comprising a coiled tension spring having a first screw on one end thereof for connecting to one end of said spring bar, and a second screw on the other end for connecting to the other end of the spring bar; and
- elongated flexible cover means having a first portion with a wear resistant surface for extending over and covering said spring bar for engaging said strings, and a second portion with a low friction surface for extending over and covering said elastic member and engaging the neck of said instrument.

10. A capo according to claim 9 wherein:
- said spring bar is curved away from the neck of the instrument so that the center of said spring bar engages the strings first.

11. A capo according to claim 10 wherein:
- said spring bar varies in cross section from the ends to the center.

12. A capo according to claim 10 wherein:
- said wear resistant surface is defined by a polyurethane or ultra high molecular weight polyethylene surface and said low friction surface is defined by a Teflon or ultra high molecular weight polyethylene surface.

13. A capo according to claim 10 wherein:
- said wear resistant surface is defined by a polyurethane sheath and said low friction surface is defined by a Teflon sheath.

14. A capo for detachably mounting on the neck of a fretted stringed musical instrument for selectively raising the pitch of the instrument comprising:
- an elongated spring bar having a length for extending across and a curved configuration for first engaging the center strings on the neck of an instrument and substantially uniformly distributing force thereto;
- an elongated coiled spring tension member connected to opposite ends of said spring bar and extending across the back of the neck of the instrument for pulling the strings into engagement with the frets of the instrument; and
- elongated flexible cover means having a first portion with a wear resistant surface for extending over and covering said spring bar for engaging said strings, and a second portion with a low friction surface for extending over and covering said elastic member and engaging the neck of said instrument.

15. A capo according to claim 14 wherein:
- said elongated elastic tension means comprises a coiled tension spring having first means on one end thereof for connecting to one end of said spring

bar, and second means on the other end for connecting to the other end of the spring bar.

16. A capo according to claim 15 wherein:
said wear resistant surface is defined by a polyurethane sheath and said low friction surface is defined by a Teflon sheath.

17. A capo according to claim 14 wherein:
a first screw on one end of said coil spring for connecting to one end of said spring bar, and a second screw on the other end of said coil spring for connecting to the other end of the spring bar.

18. A capo according to claim 17 wherein:
said spring bar varies in cross-section from the center to the ends.

* * * * *

May 12, 1959 A. T. BOURNE 2,886,224

GARMENT HANGERS

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Fig. 1.

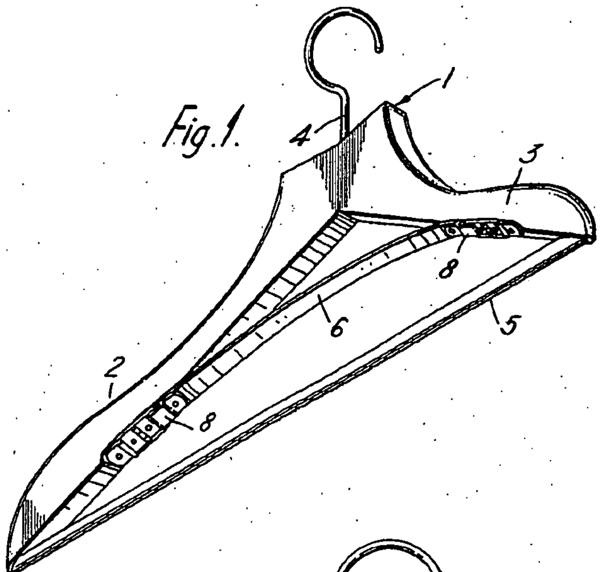
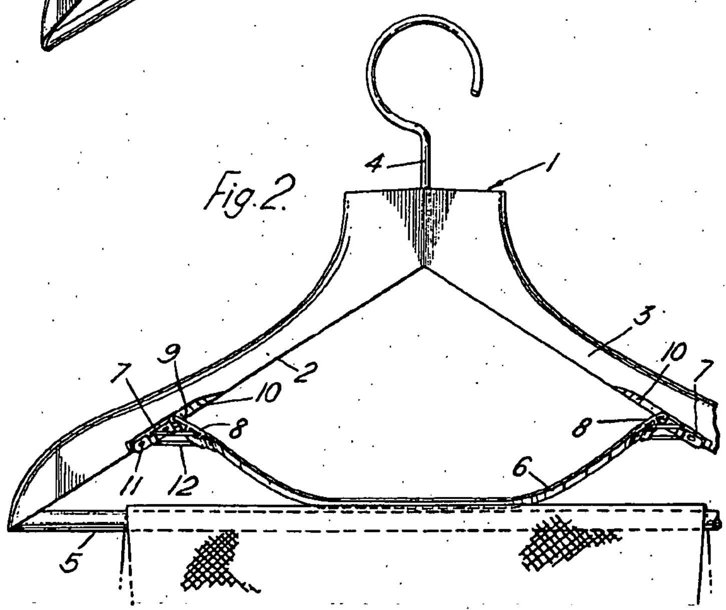


Fig. 2.



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GARMENT HANGERS

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Fig. 3.

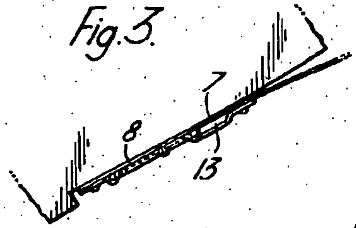


Fig. 4.

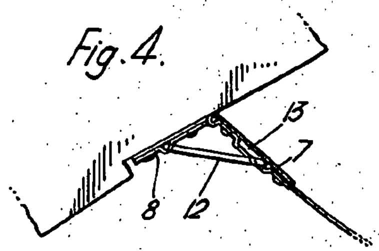


Fig. 5.

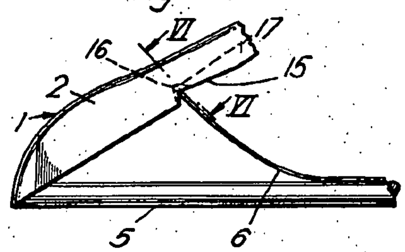
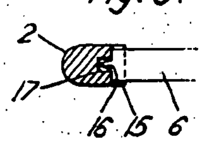


Fig. 6.



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2,886,224

Pat nted May 12, 1959

2,886,224

GARMENT HANGERS

Alfred Thomas Bourne, Torquay, England

Application September 10, 1957, Serial No. 683,110

Claims priority, application Great Britain August 18, 1956

3 Claims. (Cl. 223—91)

This invention concerns garment hangers of the kind comprising a yoke furnished with a cross rail or bar (hereinafter called a "rail") to support an auxiliary garment such as trousers, a skirt or similar garment (all hereinafter referred to as "garments"), and the object of this invention is to provide a simple and efficient means of preventing garments placed over the cross rail from slipping therefrom.

According to one aspect of this invention there is provided in or for a garment hanger having a yoke and an auxiliary garment supporting rail extending across the arms of such yoke, auxiliary garment retaining means comprising a spring element or strip flexible in only a single plane containing the axis of the said auxiliary rail, such element or strip being located within and extending between the said yoke arms and above said auxiliary rail, a hinge at each end of such element or strip, such hinges having their hinging axes perpendicular to the longitudinal axis of the spring element or strip and to said plane, and such hinges having parts thereof secured respectively to the opposite ends of said spring element or strip on one side of their hinging axes and being adapted on the other side of their hinging axes to be so secured one to each arm of the yoke of the garment hanger, and the said spring element or strip plus the parts of the hinges to which it is secured being of such a length greater than the rectilinear distance between the said yoke arms at the positions thereof to which the said spring element or strip end portions are to be secured, that the said spring element or strip is capable of being sprung in said plane alternatively between two bowed positions of opposite curvature in one of which it bears on the said rail and in the other of which it is wholly spaced from the said rail.

A hinged guide strut may be provided between the two hinge plates of each of the said hinges to limit the relative pivoting movement of such hinge plates and to assist in confining their movement to a single plane.

Said element or strip is self-adjusting automatically to accommodate, between itself and the said rail of the garment hanger, garments of moderately differing thicknesses or weights, e.g. summer weight or winter weight, whilst being self-retaining in either of its alternative positions and stable in both positions. Furthermore, the pressure exerted by the spring element or strip remains approximately the same and consequently is not likely to mark garments, e.g. thick garments, placed on the rail, due to the exertion of additional pressure because of its extra thickness.

The garment hanger may be made of any appropriate material, such as wood, aluminium, plastics, e.g. methyl methacrylate resins, steel, chrome or softer materials, and can be fabricated by any suitable constructional method or can be stamped, pressed or moulded from appropriate materials, whilst the said spring element is preferably in the form of a length of spring metal, e.g. steel, strip which may be finished, e.g. plated, in any appropriate manner.

In order that the nature of the invention may be more readily understood, reference will now be made by way of example to the accompanying drawings, wherein:

Figure 1 is a perspective view of a garment hanger having this invention applied thereto;

Figure 2 is a front elevation of the hanger shown in Figure 1 and illustrating it in use in supporting a pair of trousers on the trousers rail of the hanger;

Figure 3 is an enlarged detailed view showing the method of connecting the spring element or strip to the arms of the yoke of the garment hanger, the spring element or strip being, in this figure, shown in its inoperative position;

Figure 4 is a view similar to Figure 3, but showing the spring element or strip in its operative position;

Figure 5 is a fragmentary front elevation of the hanger shown in Figure 1, but illustrating a modified method of anchoring the ends of the spring element or strip in the arms of the hanger; and

Figure 6 is a section on the line V—V, Figure 5.

Referring to the drawings, it will be seen that the particular garment hanger there illustrated (by way of example) is of the wishbone type and comprises a yoke **1** having a pair of downwardly and forwardly divergent arms **2** and **3** and provided at its upper part with a suspension hook **4**. Across the lower ends of the arms **2** and **3** of the yoke is fixed a trousers rail **5**. The hanger so far described is of normal form and the hanger used need not be of this particular shape.

In applying this invention to such a hanger, means are provided for retaining a garment placed over the rail **5** against slipping therefrom and such means comprises a bowed spring strip **6** pivotally connected at its ends to the insides respectively of the arms **2** and **3** of the hanger, the length of the strip (and its hinging means) between the pivoting axes of the ends of the strip being greater than the rectilinear distance between the said axes themselves so that the element or strip **6** must assume either an upwardly substantially bowed position such as shown in Figure 1 or a downwardly substantially bowed position such as shown in Figure 2 and cannot rest in an intermediate position. Thus the element or strip is in the nature of an over-dead centre device which snaps to one side or the other, as required, of the straight line joining the two pivoting axes of the element or strip. Furthermore, the length of the said strip is such that in its downwardly substantially bowed position it engages the rail **5**, or a garment thereon, over a substantial distance as shown in Figure 2.

The element or strip preferably comprises a length of spring steel strip which may be chromium plated or encased in a resilient sheath and which may be about half an inch wide, each end of this strip being fixed co-linearly to one of the two hinge plates **7** and **8** of a pair of hinges **9**, each having the other of its plates secured to the inside of one of the arms **2** and **3** of the hanger **1** and which arms may have oblique flats **10** (at or formed at about 30° to the inside surface of the arm) provided for seating the hinge plates attached thereto. Conveniently the hinge plates **7** are secured to the arms **2** and **3** respectively by screws **11**.

When the element or strip **6** is in its uppermost position shown in Figure 1, the hinge plates **8** conveniently lie more or less along the insides of the arms **2** and **3** of the garment hanger, but when the spring element or strip **6** is in its operative position shown in Figure 2, the plates **8** of the said hinges are approximately at right angles to the plate **7** of the latter, somewhat as shown in the enlarged views of Figures 3 and 4 respectively.

Struts **12** in the form of stiff wire oblong loops are provided for each of the said hinges, one end of each loop being pivotally anchored to a hinge plate **8** and the

other end being slidable in a slot 13 in the other hinge plate. These struts 12 move, as the spring element or strip 6 passes from its inoperative position of Figure 1 to its operative position shown in Figure 2, from a parallel relationship with the end-to-end hinge plates 7 and 8 to the bridging or diagonal position shown in Figure 4 and serve to limit the downward hinging of the hinge plates 7.

The free upper parts 8 of the hinges 9 permit free movement up or down, as required, of the element or strip 6 only in a single plane containing the axis of the bar 5. The element or strip 6 may be pulled down merely by placing a finger on the centre thereof and pressing downwards and may be returned to its upper position conveniently by pressing the element or strip upwardly from below near its end portions (e.g. by exerting upward pressure on the struts 12) or at its centre portion. Thus to use the hanger, after placing a pair of trousers or other garment over the rail 5 while the spring element or strip 6 is in the position shown in Figure 1, all that is necessary is for the element or strip to be pressed or pulled downwards, so that it passes over its dead-centre position with a click and presses downwardly on to the garment on the rail 5 and holds the latter firmly against slipping or rolling off the rail. To release the trousers or other garment, the element 6 is pulled upwardly from the centre or pushed upwardly from the ends and snaps back into the Figure 1 position ready for future use.

Substantially steady pressure is applied along the upper edge of the rail 5 by the element 6 when in its operative position and by arranging the pivots for the element or strip 6 in a position substantially as shown and with the length of the element itself such that its end portions are roughly at about 15° to 30° to the rail when the element or strip is in its operative position, the strip levels itself out somewhat along the rail and holds the garment over a substantial length or at longitudinally spaced positions along the rail rather than at a central point.

In an alternative form of garment hanger according to this invention and shown in Figures 5 and 6, the spring element or strip has its ends directly pivoted in the arms of the yoke 1 of the hanger, instead of being connected to such arms by intermediate hinges. As shown, the ends of the spring element or strip 6 are seated in notches 15 in the arms 2 and 3, these ends being restrained against movement in a direction at right angles to the main plane of movement of the element or strip by being provided with projections or lugs 16 engaged in recesses 17 at the base of the notches 15.

Although two embodiments of the invention have been described in some detail by way of example, it should be understood that the principle of the invention could be embodied in practical form in several alternative ways and the element 6 could be, for example, in the form of a spring wire or a plurality of spring wires, which may or may not be enclosed in a rubber, plastic or other cover and which could be moved towards its alternative positions either entirely by its own springiness or with the aid of rubber or other elastic or resilient elements such as coiled springs, for example.

I claim:

1. In a garment hanger having a yoke and an auxiliary garment supporting rail extending across the arms of such yoke, auxiliary garment retaining means comprising a spring strip flexible in only a single plane containing the axis of the said auxiliary rail, such strip being located within and extending between the said yoke arms and above said auxiliary rail, a hinge at each end of such strip, such hinges having their hinging axes perpendicular to the longitudinal axis of the spring strip and to said plane, such hinges having parts thereof secured respectively to the opposite ends of said spring strip on one side of their hinging axes and being adapted on the other side of their hinging axes to be so secured one to each arm of the yoke of the garment hanger, and the said spring strip plus the parts of the hinges to which it is secured being of such a length greater than the rectilinear distance between the said yoke arms at the positions thereof to which the said spring strip end portions are to be secured, that the said spring strip is capable of being sprung in said plane alternatively between two bowed positions of opposite curvature in one of which it bears on the said rail and in the other of which it is wholly spaced from the said rail.

2. A garment hanger comprising: a yoke having two downwardly divergent arms; an auxiliary garment supporting rail extending across the said yoke between said arms; an auxiliary garment retaining device comprising a spring element flexible only in a single plane; two hinges each having two hinge plates, one each of which hinge plates of each hinge is anchored colinearly to one end portion of the said spring element and the other of which plates is secured to one of the arms of the said yoke with the longitudinal axis and flexing plane of the spring element substantially perpendicular to the pivoting axis of the said hinge plates, the said spring element being so positioned and, together with the parts of the hinges to which it is anchored, of such a length greater than the rectilinear distance between the said yoke arms at the positions thereof to which said element end portions are anchored that the said element is capable of being sprung alternatively between two bowed positions of opposite curvature in one of which it bears on the said rail and in the other of which it is wholly spaced from the said rail; and a hinged guide strut positioned between and connecting the two hinge plates of the said hinge.

3. A garment hanger comprising: a yoke having two similar downwardly and forwardly divergent arms; an auxiliary garment supporting rail extending across the said yoke between the free ends of said arms; a spring strip flexible only in a single plane containing said rail arranged between the arms of said yoke and above said rail; two hinges each having two hinge plates, one of which hinge plates of each hinge is anchored colinearly to one end portion of the said spring strip and the other of which plates is secured in a recess formed obliquely in the underside of one of the arms of the said yoke with the longitudinal axis and flexing plane of the spring strip substantially perpendicular to the pivoting axis of the said hinge plates, the said spring strip being so positioned and, together with the parts of the hinges to which it is anchored, of such a length greater than the rectilinear distance between the said yoke arms at the positions thereof to which said strip end portions are anchored that the said strip is capable of being sprung alternatively between the bowed positions of opposite curvature on one of which it bears on the said rail and in the other of which it is wholly spaced from the said rail; and a hinged guide strut in the form of a looped member connecting the plates of each said hinge, one end of each said loop being pivotally anchored to one of its associated hinge plates and the other end of the said loop being slidable in the other hinge plate.

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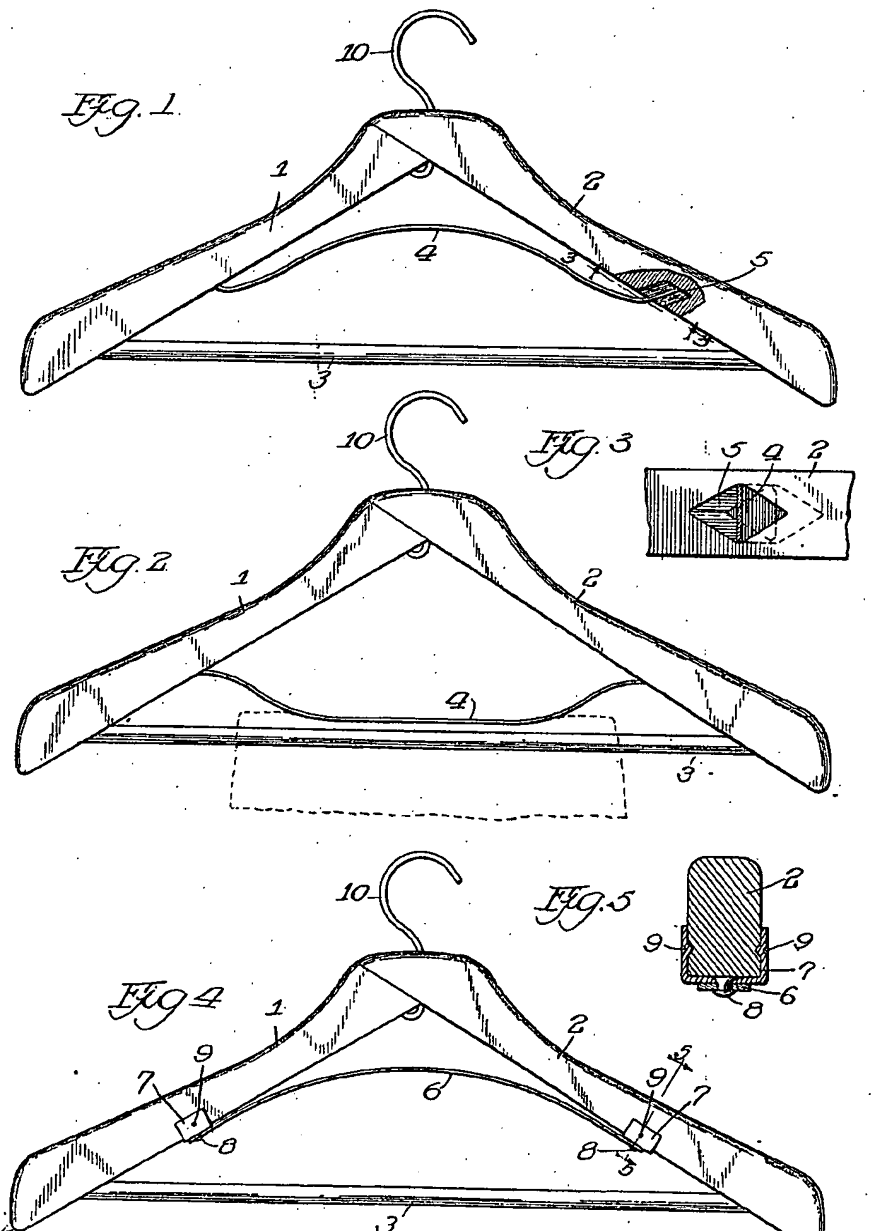
J. A. MACPHERSON.
GARMENT HANGER.
APPLICATION FILED JUNE 21, 1915.

1,206,348. Patented Nov. 28, 1916.



Witnesses:

Inventor
John A. Macpherson
By.
Atty.

UNITED STATES PATENT OFFICE.

JOHN ALEXANDER MACPHERSON, OF CHICAGO, ILLINOIS, ASSIGNOR TO BENJAMIN J. BUCKINGHAM, OF CHICAGO, ILLINOIS.

GARMENT-HANGER.

1,206,348. Specification of Letters Patent. Patented Nov. 28, 1916.

Application filed June 21, 1915. Serial No. 35,255.

To all whom it may concern:

Be it known that I, JOHN ALEXANDER MACPHERSON, a citizen of the United States, residing in Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Garment-Hangers, of which the following is a specification.

This invention relates to improvements in garment hangers of that type designed to support an entire suit of wearing apparel, such as the coat, vest and trousers of a man's suit, or the waist or jacket and skirt of a woman's suit. Such general form of hanger has been in use and the advantages of the same are well known. There is, however, a decided objection to this type of hanger. In utilizing the same it occurs frequently that the trousers, skirt, or other garment are not positioned properly on the suspension or cross bar usually employed so as to insure their retention thereon. The weight of the garment such for example of a pair of trousers when unequally disposed on opposite sides of the fold over the bar will cause the garment to slip on the bar and to fall from the hanger, and there is nothing at present provided to insure the garment remaining on the hanger unless the greatest care is exercised in distributing the weight thereof with respect to the suspension bar.

The present invention, therefore, aims to provide a garment hanger embodying in its construction simple and efficient means for obviating the objection noted, and by which a garment will be held positively on the hanger until desired for use.

I will describe my invention with particular reference to the hanging of men's suits.

The invention also has in view the provision of a garment hanger the retaining means of which, as aforesaid, are of such character as to adapt the hanger for the suspension of trousers or other garments of varying thicknesses.

With these general objects in view, and others which will appear as the nature of the improvements is better understood, the invention consists substantially in the novel construction, combination, and arrangement of parts hereinafter fully described, illustrated in the accompanying drawings and pointed out in the appended claims.

In the drawings—Figure 1 is a side elevation of a garment hanger constructed in accordance with the present invention, a portion being in section, the retainer being shown in raised, or non-restraining position. Fig. 2 is a similar view of the hanger, the retainer being lowered to illustrate its restraining position in connection with a garment shown in dotted lines. Fig. 3 is a fragmentary elevation illustrating the inner face of one of the hanger arms at the point where the receiving socket for one end of the retainer is provided, as on the line 3—3, Fig. 1. Fig. 4 is a side elevation of a garment hanger in connection with which an alternative form of retainer is employed. Fig. 5 is a transverse sectional view on the line 5—5, Fig. 4.

Referring now in detail to the accompanying drawings, the numerals 1 and 2 designate the downwardly diverging arms of a garment hanger, the upper surfaces of which are shaped or fashioned in the conventional form to adhere to the contour of the garment to be suspended, such as a coat or vest, or both. Spanning the space between the free ends of the arms 1 and 2, and suitably connected to said ends, is a horizontal suspension bar 3. Although primarily intended for use in connection with men's apparel, under which circumstances the bar 3 receives a pair of trousers, as is usual, the hanger is, of course, adapted for use with ladies' garments as well.

To avoid the objection previously noted herein—that the garment suspended by the bar 3 is liable to displacement therefrom unless carefully positioned thereon, it is the purpose of the present invention to employ means for positively coöperating with said bar to hold upon the latter any garment which may be placed on the same. To this end an elongated flexible retainer 4 is employed. This retainer is preferably in the form of a thin ribbon of steel. Its length is such that in positioning the same between the arms 1 and 2 it will assume a bowed position, as clearly illustrated in Figs. 1 and 2. The retainer 4 lies in substantial parallelism with the suspension bar 3, and for the purpose of holding the retainer in juxtaposition to said bar each of the ends of the retainer is received by a polygonal socket 5 formed in the inner face of each of the arms 1 and 2 and at a point slightly remote from the bar 3. The ends of the retainer fit in the oppositely-disposed angles of the sockets 5 and the retainer is thereby pre-

vented turning in said sockets. Engagement of the flat face of the retainer with the suspension bar 3 is thus assured. It is only necessary to thrust the ends of the retainer 4 into said sockets and the resiliency of the retainer is sufficient to hold the same in the sockets without any fastenings. The length of the retainer 4 is greater than the distance between the points at which its ends are seated on the arms 1 and 2. This permits it to be bowed or flexed at either side of the points of its connection with these arms.

By reason of the length of the retainer and the resulting bowing of the same after its ends are positioned in the sockets 5, the elasticity or resiliency due to the bowed form will hold the retainer either in the restraining position illustrated in Fig. 2, or in the non-restraining position shown in Fig. 1. Obviously it is but necessary to apply sufficient pressure to the retainer 4 to force the same to either one side or the other of a line extending between the sockets 5, whereupon the retainer will spring to restraining or non-restraining position, as determined by the position from which it is to be moved. When moved to restraining position, a substantial portion of the length of the retainer 4, due to its thin, flexible form, is in contact with the bar 3, or the garment suspended by the latter, so that pressure is exerted against the bar by the flat contact face of the retainer throughout a comparatively large portion of the length of the bar.

In Fig. 4 is illustrated a retainer of alternative form to that shown in Figs. 1 and 2. This consists of a ribbon 6 similar in all respects to the ribbon employed in the form shown in Figs. 1 and 2, but in lieu of providing sockets in the diverging arms of the hanger for the reception of the ends of the retainer, a U-shaped chip 7 is secured to each end of the retainer 6, as by riveting 8, or an equivalent fastening, and each of the clips 7 embrace the sides of the contiguous arm of the hanger to which the clip 7 is applied. The clip 7 may be attached to the hanger arms by prick punching, as at 9, or any other suitable fastening means may be substituted therefor. The advantage of the construction illustrated in Fig. 4 will be seen from the fact that the retainer therein disclosed may be applied to the conventional form of hanger now commonly used, and consisting only of the diverging arms 1 and 2 and the suspension bar 3.

The hanger is, of course, provided with the usual suspensory hook 10.

In the use of the hereindescribed hanger, if the same be employed in connection with a suit of men's apparel, the trousers are folded over the suspending bar 3 as indicated by dotted lines in Fig. 2. Obviously the retainer has been moved to non-restraining position, as illustrated in Fig. 1, before the trousers are so applied. When properly positioned upon the suspension bar 3 pressure is exerted upon the retainer 4 so that the same is caused to move to the restraining position illustrated in Fig. 2. In this movement the expansible force of the spring is shifted from above the ends of the retainer to a point below said ends, and in coöperation with the suspension bar 3 the retainer serves to hold the garment upon said bar without liability of accidental displacement. Until sufficient pressure is applied to the retainer to shift it to non-restraining position, there is no liability of the garment leaving the suspension bar. The garment is not only, therefore, firmly held in position, but it is not necessary to equalize the weight of the garment at the sides of the fold over the bar 3. It is possible in utilizing the present invention to suspend the trousers at full length from the bar 3, and thus enable the weight of the trousers to assist in retaining their shape.

Having thus described the invention, what is claimed as new, and desired to be secured by Letters Patent, is:

1. A garment hanger, comprising a pair of divergent arms, a horizontal bar extending between the free ends of said arms, and a pressure device extending from one of said arms to the other and having its ends separated from the bar, said pressure device having a flat contact face for coöperation with said bar to hold the suspended garment against movement relatively to said bar.

2. A garment hanger, comprising a pair of divergent arms, a suspension bar extending between the free ends of said arms, and an elongated flexible retainer having its ends seated on said arms at points separated from the suspension bar, said retainer being of greater length than the distance between the points at which its ends are seated on said arms, whereby to bow the retainer at either side of the points of its connection with said arms and thereby hold the retainer in restraining and non-restraining positions, the retainer when flexed toward the suspension bar coöperating with the latter to restrain movement of the garment suspended by the bar.

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United States Patent [19]

Saito et al.

[11] **Patent Number: 4,637,594**

[45] **Date of Patent: Jan. 20, 1987**

[54] **LEAF SPRING CONSTRUCTION**

[75] Inventors: **Tsutomu Saito, Chiba; Yoshimichi Hasegawa, Aichi; Kazuo Yoshikawa, Aichi; Shigetsune Aoyama, Aichi, all of Japan**

[73] Assignees: **Horikiri Spring Mfg. Co., Ltd.; Aichi Steel Works, Ltd.; Kabushiki Kaisha Toyota Chuo Kenkyusho, all of Japan**

[21] Appl. No.: **437,394**

[22] Filed: **Oct. 28, 1982**

[30] **Foreign Application Priority Data**

Oct. 29, 1981 [JP] Japan 56-174051

[51] **Int. Cl.**[4] **F16F 1/18**

[52] **U.S. Cl.** **267/47; 267/158**

[58] **Field of Search** .... 267/7, 36 R, 40, 41, 267/44, 45, 47, 158, 160, 164

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Primary Examiner—Douglas C. Butler
Assistant Examiner—Richard R. Diefendorf
Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak and Seas

[57] **ABSTRACT**

A leaf spring construction employs tapered leaf elements made from a steel sheet, where at least the tapered portion of the leaf elements have an arcuate shape in transverse cross-section with a convex surface on the tension side and a concave surface on the compression side thereof.

13 Claims, 19 Drawing Figures

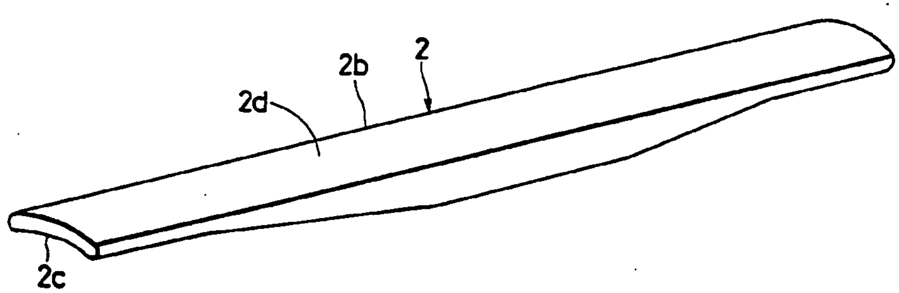

FIG. 1

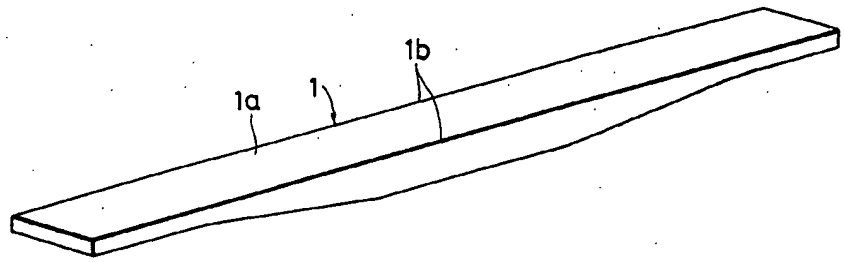

FIG. 2

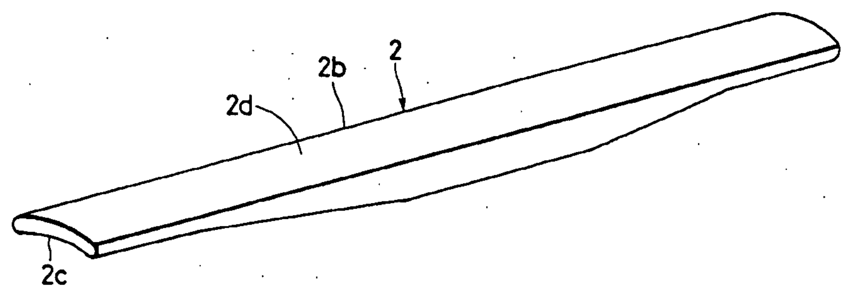

FIG. 3

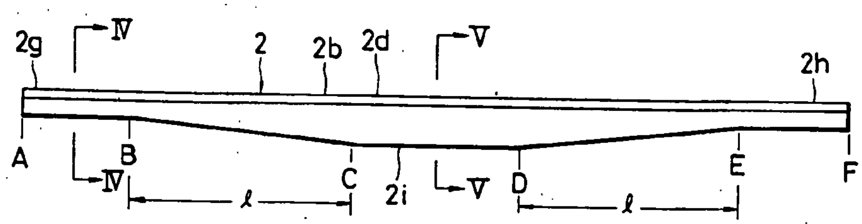

FIG. 4

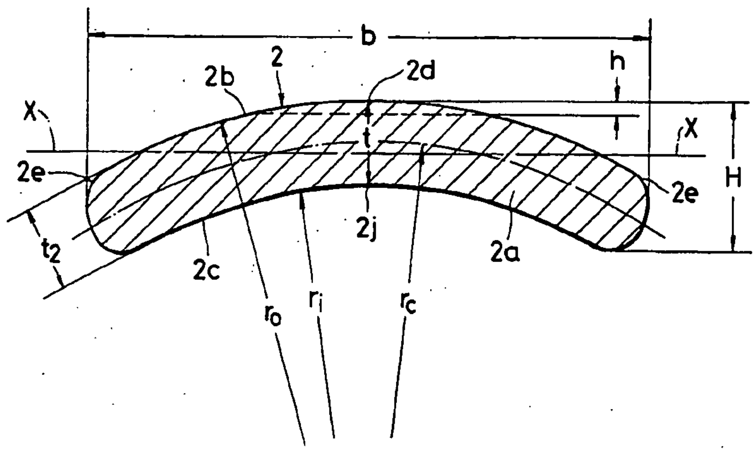

FIG. 5

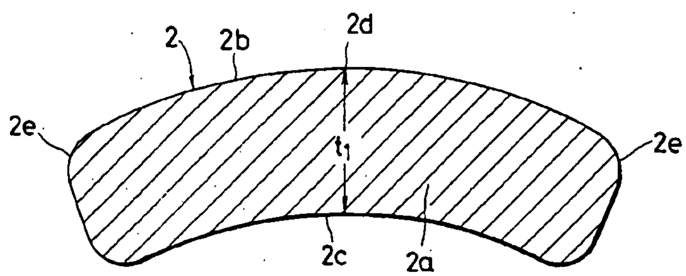

FIG. 7

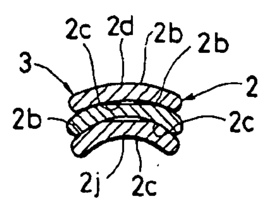

FIG. 6

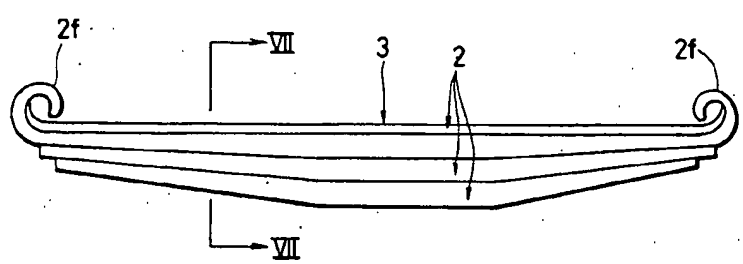

FIG. 8

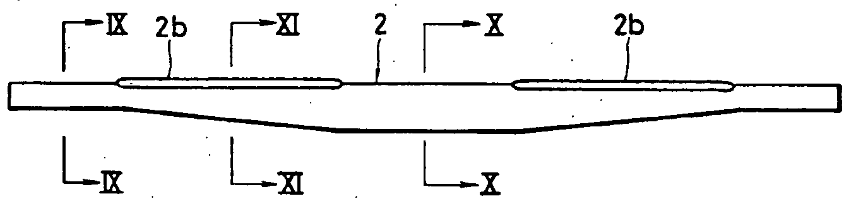

FIG. 9

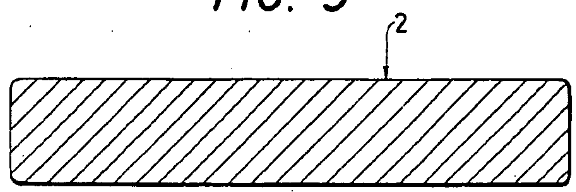

FIG. 10

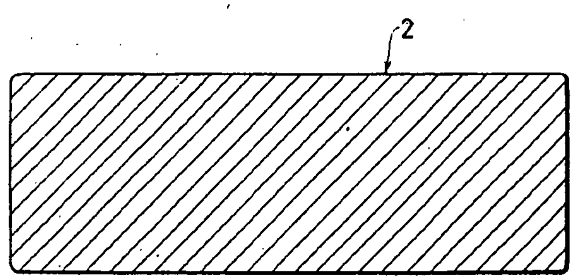

FIG. 11

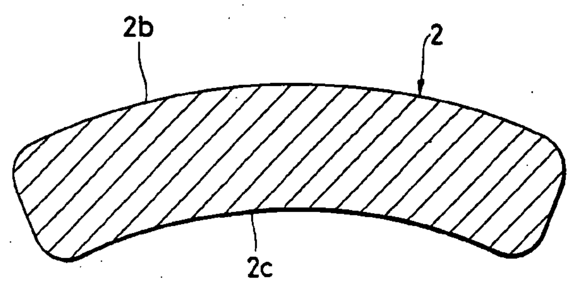

FIG. 12

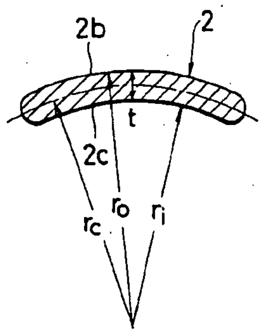

FIG. 13

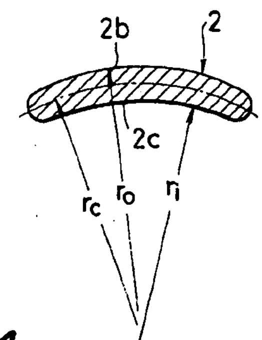

FIG. 14

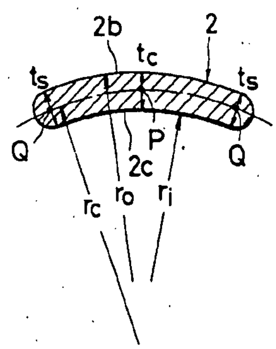

FIG. 15

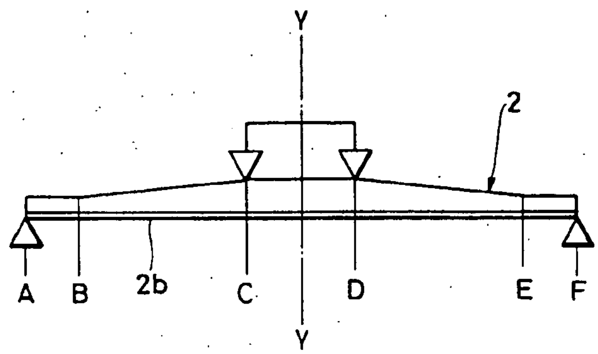

FIG. 16

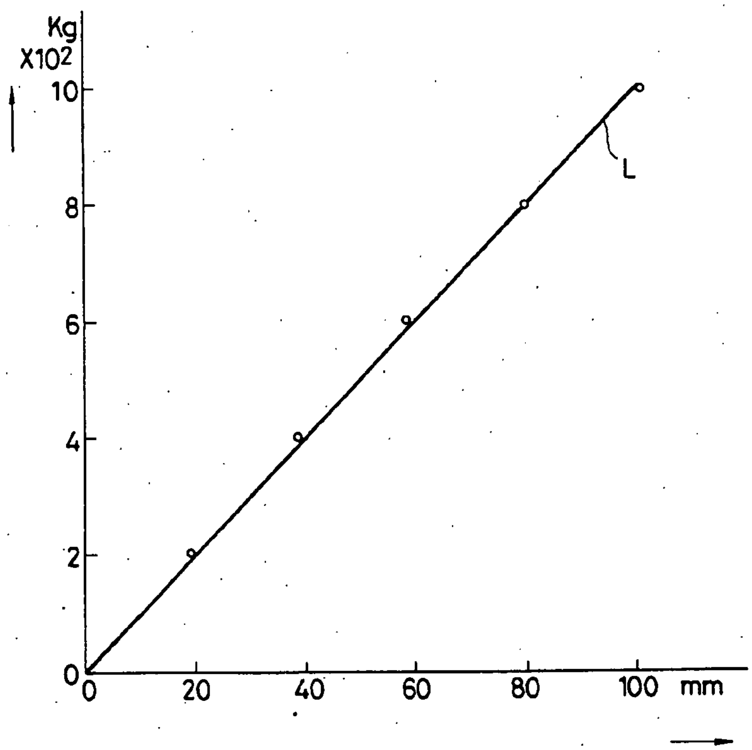

FIG. 17

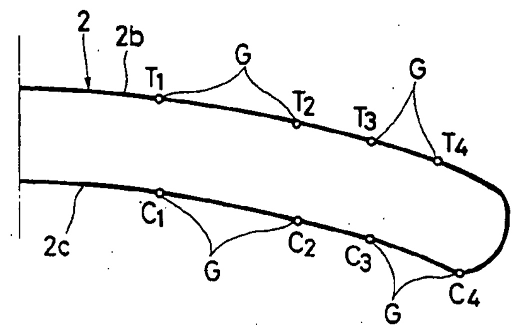
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FIG. 18

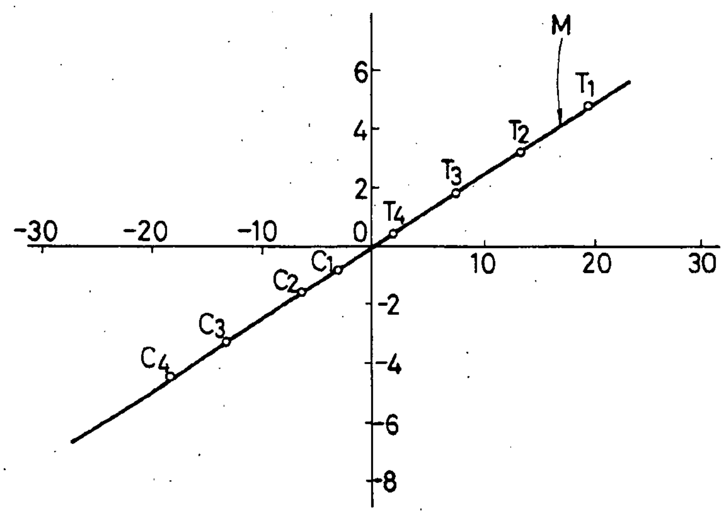
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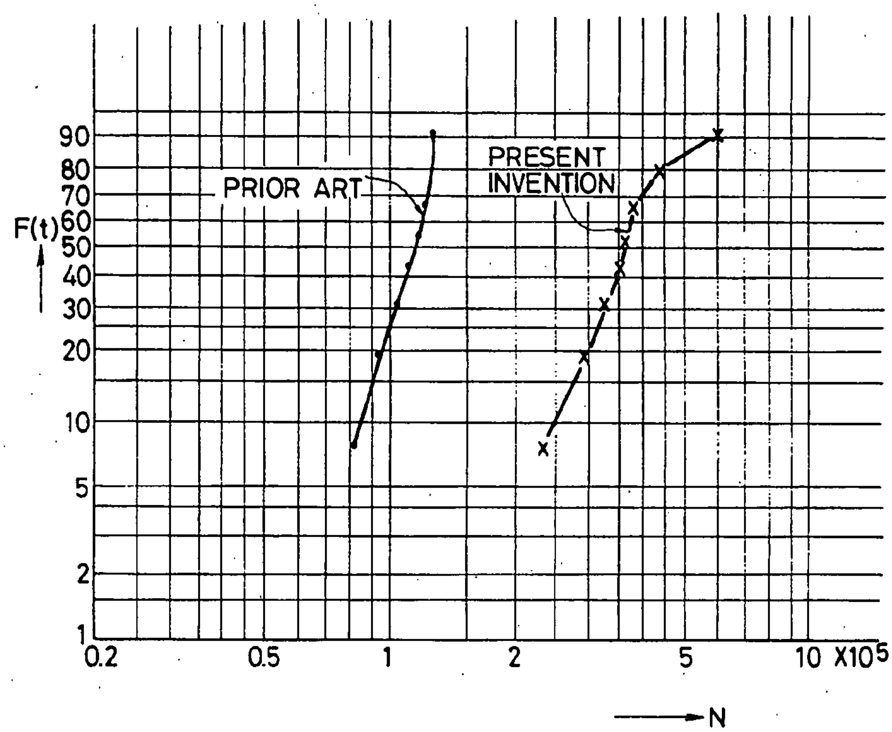
FIG. 19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LEAF SPRING CONSTRUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to improvements in and relating to a tapered leaf spring element for vehicle axle shaft suspensions, which has a reduced thickness towards opposite ends thereof, and to a laminated leaf spring comprising a plural number of such leaf spring elements.

2. Description of the Prior Art

Conventional leaf springs of this sort have a shape which is flat in a cross-section taken along a plane perpendicular to the lengths thereof so that, upon the exertion of a bending moment, concentrated stress occurs in corner edge portions of the loaded surface on the tension side, which can cause fatigue failure in these portions.

In the production of leaf springs for vehicle axle shaft suspensions, it has been the general practice to use ordinary flat rolled steel strips which have a substantially rectangular shape in a cross-section taken along a plane perpendicular to the longitudinal direction of the steel strip. In some cases there is employed a flat rolled steel strip of a trapezoidal shape, or a channel-like shape having a groove in the bottom surface in a cross-section taken along a plane perpendicular to the length of the steel strip. The reason that steel plates of the above-mentioned sectional shapes are used for the leaf spring resides in that the steel strip of such a sectional shape has a broader width on the tension side than on the compression side, in contrast with the steel strip of plain rectangular cross-section, so that the neutral axis of the sectional area is shifted toward the tension side under a bending load, thereby reducing the tension (increasing the compression) under a bending moment and increasing the amplitude of the bearable repeated bending moment per unit weight. For example, a laminated leaf spring comprising a number of leaf elements of the grooved or trapezoidal cross-sectional shape, which is widely used in vehicular suspensions, is subjected to a mean bending moment due to a static load as well as a variable amplitude bending moment due to a dynamic load. Improvements in the fatigue strength per unit weight of such springs have been attempted utilizing the fact that the fatigue strength is higher on the compression side of the beam than on the tension side under a mean bending moment due to a static load.

However, in contrast with the steel strip of simple rectangular cross-sectional shape, greater difficulties are involved in rolling a leaf element of a cross-sectional shape as shown in FIG. 2 or 3 within a prescribed tolerance, in addition to increases in the rolling cost. Further, leaf elements having conventional cross-sectional shapes are disadvantageous in that fatigue fracture is apt to occur at the corner edge portions of the transverse cross-sectional shape on the tension side where a concentration of stress takes place, exhibiting a fatigue strength about 20% lower than that of a round bar spring (a spring having round cross-sectional shape) which has no such critical edge portion.

In order to resolve these problems it has been proposed to provide a leaf spring element of a particular cross-sectional shape which is designed to lower the stress on the tension side as compared with that on the compression side, to preclude stress concentration at the corner edge portions.

U.S. patent application Ser. No. 256,784 filed on Apr. 23, 1981 continuation application Ser. No. 518,766 filed on Aug. 1, 1983 in which three of applicants are the same as in this application discloses a leaf spring element which has a circularly arcuate shape with a convex surface on the tension side and a concave surface on the compression side in a transverse cross-section, and in which the neutral axis is shifted toward the tension side to reduce the tensile stress under a bending moment.

However, as is clear from beam theory, the bending stress acting on the leaf spring varies along the length thereof, and the stress is smaller at a portion, farther from a center portion of unit length thereof where the stress is maximum. Since the arcuate cross-sectional shape of the proposed leaf spring is the same throughout the length thereof and the size of the cross-section is determined by the maximum bending stress, the thickness of the leaf spring becomes excessive at some portions thereof, causing the weight of the leaf spring to be excessively large.

On the other hand, a leaf spring whose width is constant and whose cross-sectional area varies along the length thereof with the thickness around the center portion being a maximum has been proposed, as shown in FIG. 1. With this leaf spring 1, the distribution of bending stress is made uniform throughout the length thereof. This leaf spring is also effective in weight reduction. That is, compared with a conventional leaf spring having the same cross-sectional area throughout its length, the leaf spring 1 allows a weight reduction of about 10 to 15% while maintaining the strength thereof and attaining uniform stress distribution.

However, since the cross-sectional shape of this spring is rectangular throughout its length, the fatique breakdown is still concentrated at edge portions 1b in the upper surface *1a*. That is, compared with an edgeless rod spring of the same material, the fatigue strength of the leaf spring 1 is less by about 20%. Therefore, the leaf spring 1 does not satisfy all of the requirements as to bending stiffness per unit weight, fatigue strength per unit weight and total weight reduction.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a tapered leaf spring having substantially uniform bending stress throughout the length thereof, which is light in weight and has a high fatigue strength.

The above object is achieved according to the present invention by shaping the vertical cross-section of a spring such that it has a circularly arcuate shape with a convex surface on the tension side and a concave surface on the compression side in the traverse cross-section, such that the neutral axis is shifted toward the tension side to reduce the tensile stress under a bending moment to thereby improve the flexural rigidity and fatigue strength per unit weight, and such that the portion thereof to which the maximum bending stress is applied causing fatigue breakdown is shifted to an apex portion of the convex surface to eliminate the possibility of fatigue breakdown due to the presence of an edged corner portion.

Another bject of the present invention is to obtain a satisfactory effect in the shot peening of the spring by causing the sh t to collide with the apex portion of the convex surface at substantially right angles thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and attendant advantages of the present invention will become apparent from the following detailed description and appended claims, taken in conjunction with the accompanying drawings in which like reference characters designate like or corresponding parts through various figures, and wherein:

FIG. 1 is a perspective view of a conventional tapered flat leaf spring;

FIG. 2 is a perspective view of a leaf element illustrating a first embodiment according to the present invention;

FIG. 3 is a side view showing a second embodiment of the present invention;

FIG. 4 is a cross-section taken along line IV—IV of FIG. 3;

FIG. 5 is a cross-section taken along line V—V of FIG. 3;

FIG. 6 is a side view of a leaf spring constituted by a plurality of the leaf spring elements shown in FIG. 3;

FIG. 7 is a cross-section taken along line VII—VII of FIG. 6;

FIG. 8 is a side view of a third embodiment of the present invention;

FIG. 9 is a cross-section taken along line IX—IX of FIG. 8;

FIG. 10 is a cross-section taken along line X—X of FIG. 8;

FIG. 11 is a cross-section taken along line XI—XI of FIG. 8;

FIG. 12 illustrates a cross-sectional shape in which the convex and concave surfaces are coaxial;

FIG. 13 illustrates a cross-sectional shape in which the surfaces have common curvature;

FIG. 14 illustrates a cross-sectional shape in which the surfaces have arbitrary curvatures;

FIG. 15 is a side view showing testing conditions of the present leaf spring;

FIG. 16 is a diagram showing the deflection-load characteristics of the present leaf spring element;

FIG. 17 shows the locations on a leaf spring element half at which gauges are mounted;

FIG. 18 is a graph showing the stress distribution in the element half of FIG. 17; and

FIG. 19 is a diagram showing the endurance limit of the present leaf spring element against repeated bendings, in comparison with the conventional tapered spring.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the accompanying drawings and initially to FIGS. 2 to 5, there is shown a first embodiment of the leaf spring element to be used in the laminated leaf spring according to the present invention, in which FIG. 2 is a perspective view of the spring element, FIG. 3 is a side view thereof, FIG. 4 is a cross-section taken along line IV—IV of FIG. 3 and FIG. 5 is a cross-section taken along line V—V of FIG. 3.

In FIGS. 2 and 3, the tapered leaf spring 2 of the present invention is characterized by a thickness which is at a maximum at around the center portion thereof and which decreases continuously towards opposite ends thereof, so that the bending stress distribution is substantially uniform throughout the spring length. In cross-section, the spring has a shape which includes a convex surface 2b on which tension is applied and a concave surface 2c on which compressive stress is applied under the bending moment, so that the neutral axis in the cross-section is shifted toward the tension side thereof. The portions at which the maximum bending stress occur are outside the corner portions *2e*, to avoid fatigue breakdown thereat.

With the tapered shape of the present leaf spring element, the relation between the length l defined between points B and C or between D and E of the tapered portion thereof and the difference Δt between the maximum thickness t_1 of the portion between points C and D and the minimum thickness t_2 of portion between the points A and B or between E and F can be represented by

$$0.005 \leqq \Delta t/l \leqq 0.15$$

and more preferably,

$$0.005 \leqq \Delta t/l \leqq 0.03$$

That is, if $\Delta t/l$ is smaller than 0.005, the reduction rate of the weight is too small, and if it is larger than 0.15, manufacture of the leaf spring becomes difficult. If $\Delta t/l$ is selected between 0.005 and 0.15, and preferably between 0.005 and 0.03, the manufacturing cost as well as the reduction rate of the weight of the leaf spring element becomes satisfactory.

As shown in FIG. 4 the leaf spring 2 has a width b and a transverse center line having a radius of curvature r_c such that

$$2.0 \geqq r_c/b \geqq 0.64$$

to ensure higher rigidity and excellent fatigue strength per unit weight as compared with flat springs, coupled with accompanying effects such as the reduction of irregularities in flexural rigidity due to errors in the radius r_c which occur during the fabrication process, as well as a reduction in weight. If r_c/b is larger than 2.0, the spring constant and weight thereof come to the same level as those of the conventional rolled flat spring, and if it is smaller than 0.64, the cross-sectional secondary moment due to errors in the curvatures of the arc surfaces in forming the flat steel into an arc varies too much, lowering the possibility of obtaining an effective spring.

The plate thickness t of the above-mentioned cross-section is held in the range

$$0.5 \geqq t/b \geqq 0.05$$

to improve the roll-forming characteristics, to enhance the surety and efficiency and to utilize the margin of the fatigue strength on the compression side. If the ratio t/b exceeds 0.5, it becomes difficult to utilize the fatigue strength to a sufficient degree, while a ratio of t/b lower than 0.05 is beyond the limit of hot working and makes the forming operation difficult. In this case, when the spring can have a center portion in which t/b is large and has a little improvement in rigidity or when the spring must have a flat center portion for mounting to a vehicle, it may be possible to make the cross-section thereof rectangular. This is also applicable where eyes are to be formed at the pposite ends of the spring.

Further, the radius of curvature r_o of the arcuately convex surface *2b* and the radius of curvature r_i of the

concave surface 2c of the leaf spring are held in the range

$$1.2 \geqq r_o/r_i \geqq 1.0$$

so that when a plurality of the spring elements 2 are used in overlapping relation to form a composite spring 3 (FIG. 6) a gap of a predetermined width is formed between and at a median point along the width of the opposing convex and concave surfaces to prevent fretting and corrosion at the ends of the center clamp and the leaf ends of short leaf elements, ensuring improved fatigue strength. When the ratio of r_o/r_i is smaller than 1.0, the center portion of the convex surface 2b contacts the concave surface 2c of an adjacent leaf element, while a value in excess of 1.2 will result in decreasing the damping effect.

Further, a leaf spring is provided with a flat surface at the center apex portion of its convex surface truncated in parallel with a line connecting opposite ends of the leaf element in the transverse cross-section, the depth of truncation h relative to the leaf thickness t being

$$0.35 \geqq h/t \geqq 0$$

The provision of the truncated surface contributes to lowering the geometrical moment of inertia with a modulus of the section substantially similar to that of a non-truncated leaf element, that is to say, to lower the flexural rigidity alone without varying the stress or the fatigue strength, coupled with a practical advantage that surface flaws or a decarburated layer can be removed by grinding or cutting the truncated surface.

Further, in forming the laminated spring by overlapping a plurality of the arcuate tapered spring elements 2 and binding then together at suitable locations along the length thereof as shown in FIG. 6, the respective convex surfaces 2b are contacted with the concave surfaces 2b of the adjacent spring elements without direct contact between the apex portions 2d of the convex surfaces and the concave surfaces, leaving spaces proximate the apex portions 2d, respectively, as shown in FIG. 7, and some of the spring elements are resiliently deformed widthwisely by the binding. With this laminated structure, when a bending load is applied with the opposite ends of the spring supported by supporting members, respectively, the laminated spring 3 has excellent bending rigidity and fatigue strength per unit weight.

FIGS. 8 to 11 show a second embodiment of the present invention, in which FIG. 8 is a side view, FIG. 9 is a cross-section taken along line IX—IX of FIG. 8, FIG. 10 in a cross-section taken along line X—X of FIG. 8 and FIG. 11 is a cross-section taken along line XI—XI of FIG. 8. In this embodiment, the cross-sectional shape of the center portion and the opposite end portions is rectangular and the shape of the remaining tapered portion is made arcuate. Although not shown, it is also possible to make the center portion and the tapered portions arcuate and the opposite end portions rectangular.

Now, the selection of the radius of curvature of the upper and lower surfaces of the arcuate cross-sectional portions will be described with reference to FIGS. 12 to 14.

The upper surface 2b and the lower surface 2c of the arcuate cross-sectional portion of the tapered spring element 2 in FIG. 12 have curvature radii r_o and r_i, respectively, which are concentric, with the difference between r_o and r_i being the thickness t of the spring element.

In FIG. 13, the radii r_o and r_i of the upper and lower surfaces 2b and 2c are made equal and, in FIG. 14, r_o and r_i are selected arbitrarily unless there is no substantial variation in thickness throughout the cross-section.

The radius r_c of the neutral plane of the spring element 2 in FIG. 12 can be calculated by subtracting half of the plate thickness t from the radius r_o of the upper surface 2b. The radius r_c for the case in FIG. 13 can also be calculated in a similar manner. However, as shown in FIG. 14, it may be obtained by generating a circle passing through a median point P of the thickness t_c at the center portion of the tapered spring element 2, and median points Q of the thickness t_r at the end portions of the element 2, and determining the radius of this circle.

The effect of the spring element thus constructed will now be described. Firstly, it is considered that whether or not tapered, an arcuate spring provides a deflection similar to that provided by a flat cantilever. According to experiments, the deflection of the arcuate element is largely coincident with the deflection amount of a cantilever calculated according to beam theory. With regard to the stress distribution under a bending moment, this is also largely coincident with the theoretically calculated value.

In the tapered spring element 2 shown in FIG. 15, the distances of points C, D, B, E, A and F from a center line Y arm 50 mm, 50 mm, 350 mm, 400 mm, and 400 mm, respectively. The plate thickness t_c (at the median portion in cross-section) of the portion between the points C and D is a constant 10 mm, the thickness of the portion between C and B as well as between D and E varies from 10 mm to 6 mm and the thickness of the portions between B and A as well as between E and F is a constant 6 mm. The width b of the plate is 70 mm and the radius of curvature r_c is 90 mm.

This spring element 2 was supported at points A and F so that tension stress acted on the convex surface 2b, and a load was applied at points C and D. The deflection at the points C and D was then measured.

FIG. 16 shows the results of this measurement. In FIG. 16, the results shown by the circles coincide well with a solid line L, which is a plot of deflection values as calculated according to beam theory.

In the above measurement, strain gauges G were bonded to points T_1 to T_4 on the upper surface 2b and to points C_1 to C_4 on the lower surface 2c of the spring element 2, as shown in FIG. 17 to measure the stress at these points, which was then plotted as shown in FIG. 18. The result is coincident with a solid line M, which is a plot of the stress distribution calculated according to beam theory.

From these experiments and the results thereof, it will be clear that the tapered spring element 2 according to the present invention can be used as a resilient beam in way similar to the conventional flat spring.

For comparison purposes, the present tapered springs 2 and conventional tapered springs having a rectangular cross-section were prepared under the same conditions and tested for fatigue to determine the average endurance thereof. The tapered spring 2 used was that shown in FIG. 15, and the conventional tapered spring prepared had the same thickness distribution as that of the spring 2, the material of these springs being SUP9 as specified by the Japanese Industrial Standard.

The springs are annealed under the same conditions and then subjected to shot-peening treatment at the surfaces thereof. The hardness of the springs after heat treatment was 3.05 (BHD).

The present tapered spring 2 used in the test had concentric upper and lower surfaces *2b* and *2c* as shown in FIG. 12.

The fatigue test was performed under the condition of an average tensile stress of 65 kg/mm^2 and a stress amplitude of 55 kg/mm^2. The results of this fatigue test, i.e., the breakdown or failure probability of the present spring 2 (shown by X's) and that of the conventional tapered spring (shown by dots) are shown in FIG. 19. From FIG. 19, it can be seen that the endurance of the present tapered spring 2 is about three times that of the conventional tapered spring in terms of the number of cycles to failure. It should be noted that in this test that the upper surface *2b* of the present spring 2 was the tension stress side and a deflection was applied to that surface repeatedly.

The present tapered spring 2 has a fatigue strength similar to that of a rod spring having a circular cross-section due to that fact that the point at which the maximum tension acts is shifted to around the apex portion of the convex surface *2b* on the tension side. The notch effect at the corners of the tension side where fatigue cracks formerly began to occur is removed. Further, when the peening treatment is performed at the surface of the tension side to improve the strength of the black skin decarbonized layer after heat treatment of the hot rolled spring steel material, the shot can collide at about a right angle with the convex surface *2b* at which the possibility of fatigue breakdown is high, resulting in a satisfactory peening effect. The latter effect is considerable in comparison with the conventional tapered leaf spring which has corners at which the possibility of fatigue breakdown is very high, as it is hard to perform the shot peening treatment.

As to the fabrication of the present tapered leaf spring 2, by setting the width b, the thickness t, the radius of curvature r_i of the concave surface *2c*, the radius r_o of the convex surface *2b* and the radius r_c of the median plane in the ranges mentioned previously, it becomes possible to minimize the variation of bending rigidity due to manufacturing errors in the radius r_c, and to minimize the weight, resulting in facilitated and reliable formation of the leaf spring.

Further, as to the shot peening treatment to be performed on the average tension side to strengthen the decarbonized layer of the spring, this is difficult to perform for the corners of flat leaf spring. However, it is easy to do with the present leaf spring 2 because the area which is most prone to fatigue breakdown is shifted to the apex portion *2d* of the convex surface *2d*, which has a large radius of curvature with which the shot can collide at about a right angle.

When the leaf spring elements 2 are used to form a laminated spring 3 as shown in FIGS. 6 and 7, a suitable gap is formed between the apex portion *2d* of the convex surface *2b* of one spring element 2 and the bottom portion *2j* of the concave surface *2c* of the adjacent spring element 2. Therefore, fretting can be prevented at portions corresponding to edge portions of the clamping member and/or edge portions of a short leaf, resulting in a considerable effect on the fatigue limit.

In addition, by providing a truncation in the apex portion *2d* of the spring element 2 in the range mentioned above, a suitable space is formed between the adjacent spring elements 2 of the laminated leaf spring 3 even if the radii r_i and r_o of the respective elements are equal. The grinding or cutting of the apex portion in providing the truncation can remove any surface defect and the decarbonized layer of that portion, causing the fatigue strength of the spring element to be further improved.

As to weight reduction, the employment of an arcuate cross-section attributes to a reduction of about 15%, and the employment of the tapered configuration attributes to about a 5 to 10% reduction in comparison with the conventional flat leaf spring element. Therefore, it is possible to increase the usable stress per unit weight by about 20 to 30% over that of the flat leaf spring.

Further, since the ratio of the compression stress to the tension is higher than that of the flat spring by about 30%, it is possible to considerably reduce the spring weight per load, and fatigue testing performed under the same stress amplitude conditions shows that the number of cycles to failure of the present leaf spring element is three times that of the flat leaf spring element, as mentioned above.

As described hereinbefore, the present leaf spring element is characterized by a utilization of a tapered configuration and an arcuate cross-sectional shape. Therefore, it is possible to shift the median axis of bending moment toward the surface at which the maximum tension stress occurs and to shift the portion of the spring where tension stress is concentrated to a location away from the corners, as was the case with the conventional leaf springs having a rectangular cross-section, to thereby prevent damage to the leaf spring due to material defects in such corner portions. Thus, the fatigue strength of the present leaf spring is increased up to that of a spring rod having a circular cross-section, and an increase of usable stress and a reduction in the weight of the leaf spring can be attained.

When the leaf spring element according to the present invention having such advantages as mentioned hereinbefore is used in the construction of the leaf springs of a vehicle, the reliability of the vehicle is improved, and the leaf springs contribute to a reduction of the weight and consequently the fuel consumption of the vehicle.

What is claimed is:

1. A leaf spring comprising: a single spring steel plate adapted to undergo bending deformation in a direction perpendicular to the length and parallel to the thickness thereof;

a center portion of said plate in the lengthwise direction thereof having a constant maximum thickness, the thickness gradually decreasing toward opposite ends of the plate to form tapered portions;

at least said tapered portions having an arcuate shape in transverse cross-section, with a convex surface on a tension side and a concave surface on a compression side thereof, said convex and concave surfaces being defined by an arc of substantially the same radius over the entire width thereof, respectively, and said arcuate shape satisfying the relation:

$$2.0 \geqq r_c/b \geqq 0.64$$

where b is the width of said plate and r_c is the radius f a transverse center line of said plate; and

said tapered portions satisfying the relation:

$$0.03 \geqq \Delta t/l \geqq 0.005,$$

where l is the length of each said tapered portion and at is a difference in thickness between opposite ends of each said tapered portion;

thereby providing a single tapered spring with a reduced weight as well as both flexual rigidity and fatigue strength improved per unit weight of the leaf spring.

2. The leaf spring according to claim 1, wherein said plate has, in said cross-section, a thickness t such that

$$0.5 \geqq t/b \geqq 0.05.$$

3. The leaf spring according to claim 2, wherein said convex surface has a radius of curvature r_o and said concave surface has a radius of curvature r_i and a relationship between r_o and r_i satisfies:

$$1.2 \geqq r_o/r_i \geqq 1.0.$$

4. The leaf spring according to claim 3, wherein said convex surface on said tension side has an apex portion, said apex portion being truncated to form a planar surface portion parallel to a line connecting opposite ends of said steel plate, the depth of truncation h relative to the plate thickness t being such that

$$0.35 \geqq h/t.$$

5. The leaf spring according to claim 1, wherein said center portion and said opposite ends have a rectangular cross-section and said tapered portions have said arcuate cross-section.

6. The leaf spring according to claim 1, wherein at least the tension side of said plate is subjected to peening to increase the strength thereof.

7. A laminated leaf spring comprising:

a plurality of steel plates, each being adapted to undergo bending deformation in a direction perpendicular to the length thereof and parallel to the thickness thereof;

a center portion of each of said plates in the lengthwise direction having a constant, maximum thickness, the thickness gradually decreasing toward opposite ends of the plate to form tapered portions;

at least said tapered portions having an arcuate shape in transverse cross-section, with a convex surface on a tension side and a concave surface on a compression side thereof, said convex and concave surfaces being defined by an arc of substantially the same radius over the entire width thereof, respectively, and said arcuate shape satisfying the relation:

$$2.0 \geqq r_c/b \geqq 0.64$$

where b is the width of said plate and r_c is the radius of a transverse center line of said plate; and

said tapered portions satisfying the relation:

$$0.03 \geqq \Delta t/l \geqq 0.005,$$

where l is the length of each said tapered portion and Δt is a difference in thickness between opposite ends of each said tapered portion:

thereby providing a laminated leaf spring with a reduced weight as well as both flexural rigidity and fatigue strength improved per unit weight of the leaf spring.

8. The laminated leaf spring according to claim 7, wherein each said plate has, in said cross-section, a thickness t such that:

$$0.5 \geqq t/b \geqq 0.05.$$

9. The laminated leaf spring according to claim 8, wherein said convex surface has a radius of curvature r_o and said concave surface has a radius of curvature r_i and a relationship between r_o and r_i satisfies:

$$1.2 \geqq r_o/r_i \geqq 1.0.$$

10. The laminated leaf spring according to claim 9, wherein said convex surface on said tension side has an apex portion, said apex portion being truncated to form a planar surface portion parallel with a line connecting opposite ends of said steel plate, the depth of truncation h relative to the plate thickness t being such that:

$$0.35 \geqq h/t.$$

11. The laminated leaf spring according to claim 7, wherein each said center portion and said opposite ends have a rectangular cross-section, and said tapered portions have said arcuate cross-section.

12. The laminated leaf spring according to claim 7, wherein each of said plates have a curvature such that, when laminated, a gap is formed between the apex of a convex surface of one plate and the concave surface of an adjacent plate.

13. The laminated leaf spring according to claim 7, wherein at least the tension sides of said plates are subjected to peening to increase the strength thereof.

* * * * *

[54] ELASTICALLY YIELDABLE DEVICE FOR FIXING A RAIL ON A SUPPORT

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[21] Appl. No.: 290,055

[22] Filed: Aug. 4, 1981

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 179,880, Aug. 20, 1980, abandoned.

[30] **Foreign Application Priority Data**

Jun. 30, 1980 [FR] France 80 14523

[51] Int. Cl.³ E01B 9/00; E01B 9/48
[52] U.S. Cl. 238/349; 238/310
[58] Field of Search 238/310, 315, 324, 321, 238/343, 349, 360

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[57] **ABSTRACT**

The device comprises a spring fixed to a support at a point remote from the rail and curved in the direction of the rail, and a swing block interposed between the spring and the flange of the rail. The swing block bears against the flange of the rail at one end and against the support at its opposite end. The swing block is clamped by the end of the spring which applies a clamping force at point located at a distance from the flange of the rail but in the vicinity of the flange so that the two lever arms of the swing block have very different lengths. Further, the spring has a thickness which decreases in the direction of the rail and bears against the swing block by its end which is curved, the swing block having a corresponding shape under said end.

14 Claims, 8 Drawing Figures

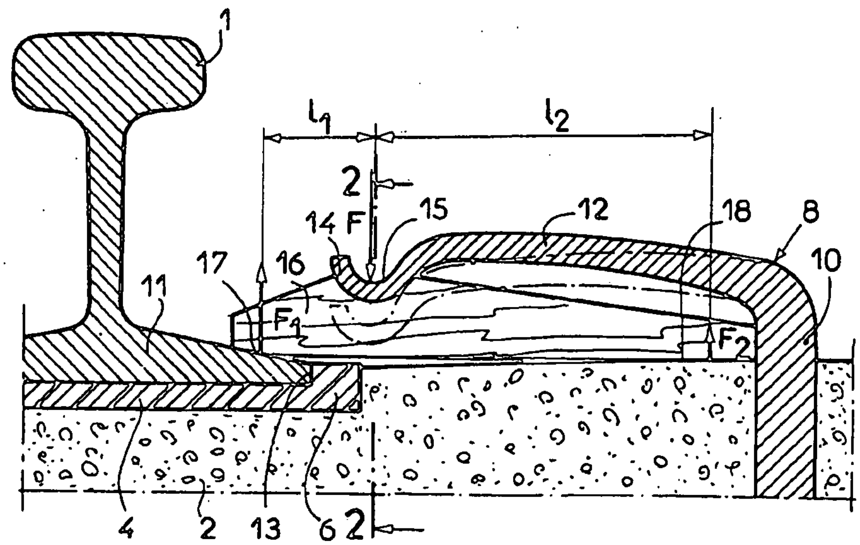


FIG.1

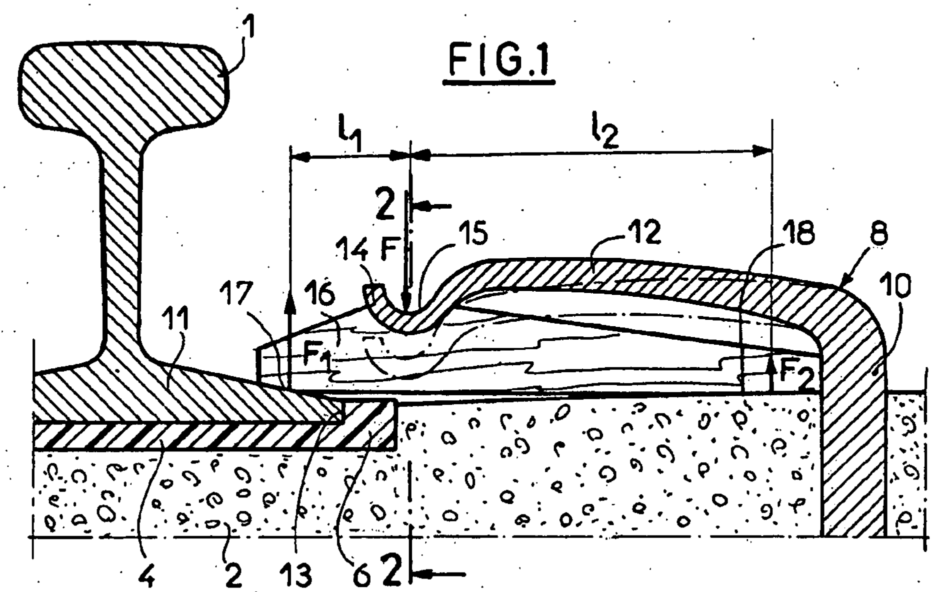
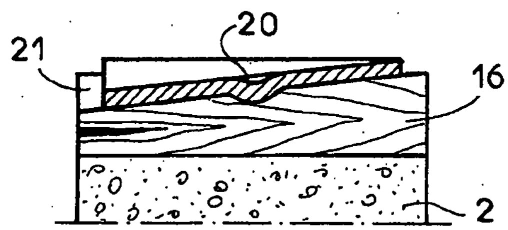


FIG.2



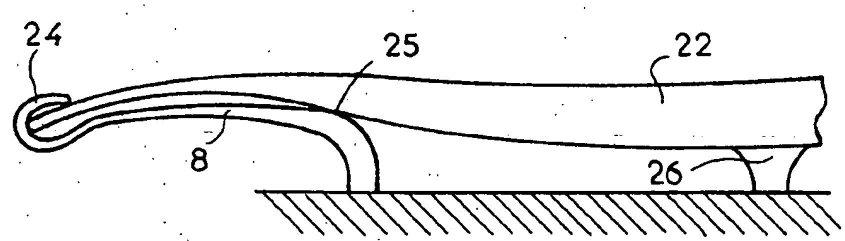


FIG.3

FIG.4

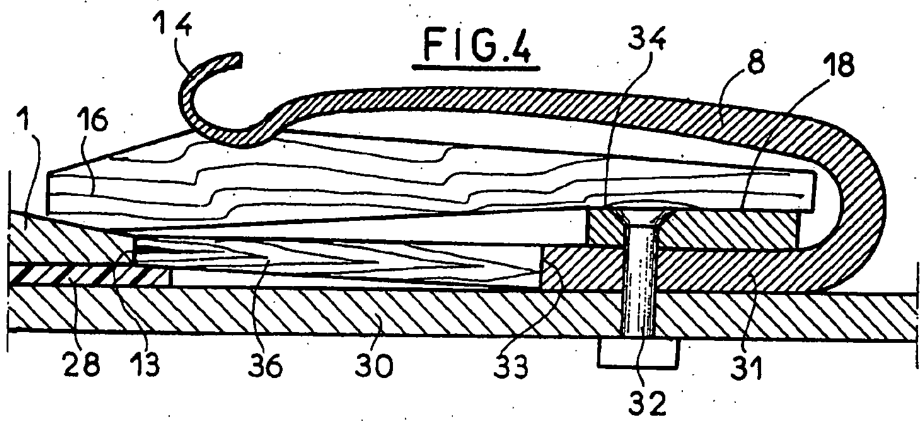


FIG.5

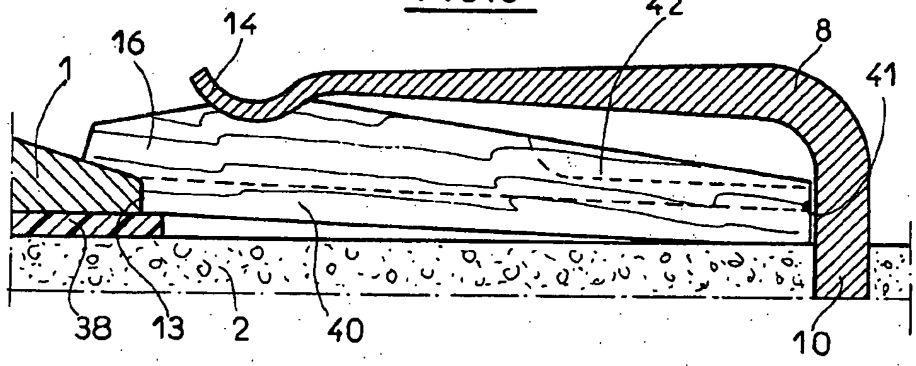
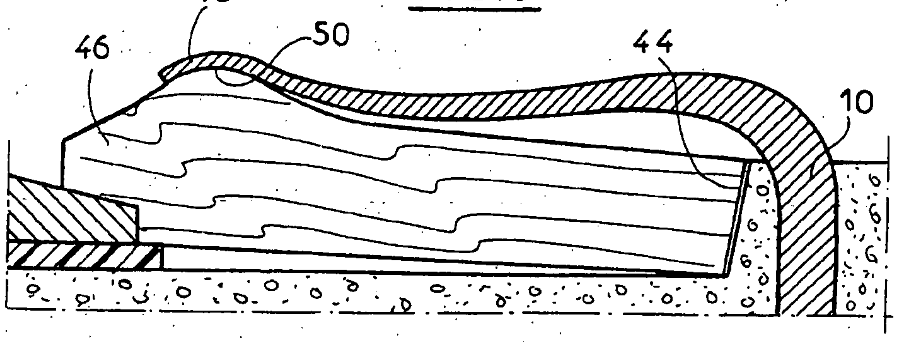


FIG.6



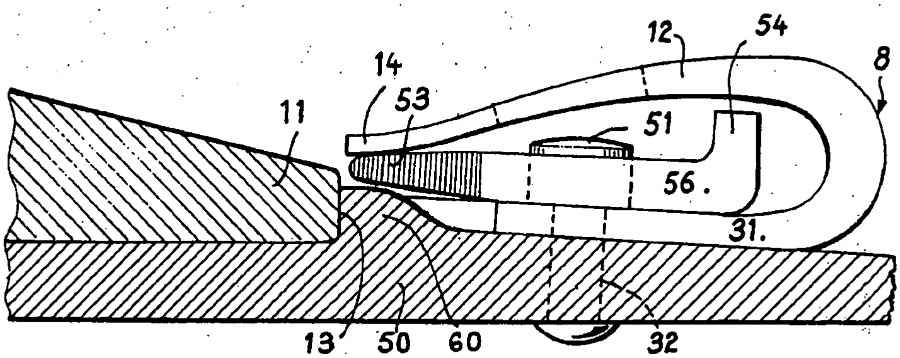


FIG.7

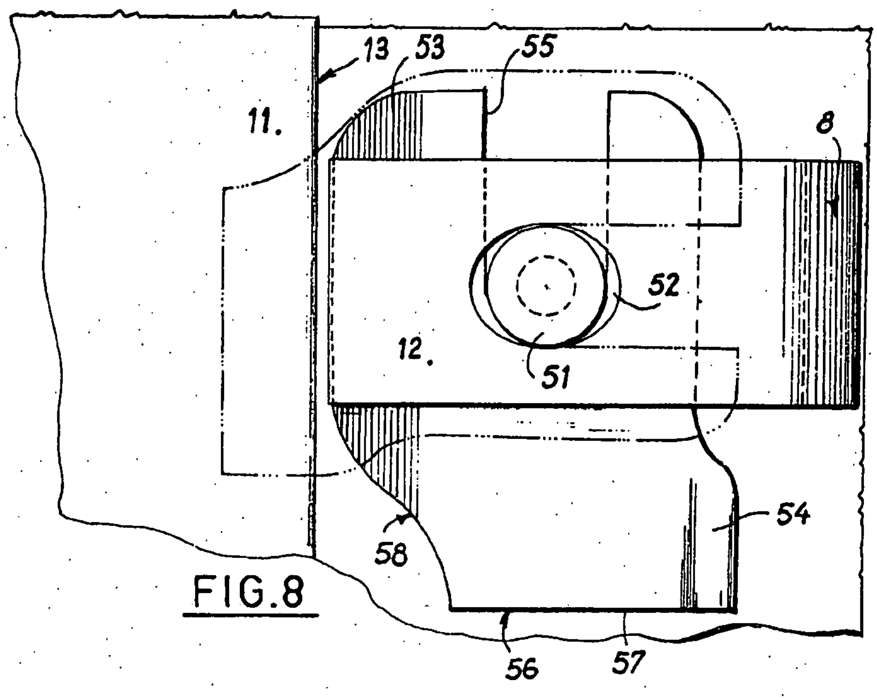


FIG.8

ELASTICALLY YIELDABLE DEVICE FOR FIXING A RAIL ON A SUPPORT

DESCRIPTION

This application is a Continuation-In-Part of U.S. application Ser. No. 179,880, filed Aug. 20, 1980, now abandoned.

The present invention relates to an elastically yieldable device for fixing a rail on its support, of the type comprising a spring which is put under stress between an anchoring member and the flange of the rail when mounting the rail and which thus exerts a clamping force on this flange without the use of bolts, screws or like means.

It is well known that the fixing devices of this type have the great advantage of avoiding the risk of excessive tightening and the risk of an accidental untightening. However, the use of these devices involves a serious drawback residing in the difficulty of placing the rail in its exact position on its support. Further, the spring and the anchoring member are metal components and it is usually necessary to interpose an insulating member between the rail flange and each of these components. Now, this insulating member is subjected to very severe working conditions since it is subjected to both high compression forces and wear resulting from the relative movements between the rail flange bearing on an elastically yieldable sole member and the anchoring member fixed to the support. Consequently, it is liable to deteriorate in a premature and dangerous manner.

In order to overcome this problem, there has been proposed a rail fixing device comprising a spring which is rigid with the support at one of its ends and is curved in the direction of the rail but does not reach the latter, and exerts a force on an intermediate member which bears against this rail. Such an arrangement enables the spring to be fixed previously and permanently, a long and narrow intermediate member being introduced under the spring and parallel to the rail after the installation of the latter between the rail and a lateral abutment.

However, this device does not permit obtaining a satisfactory distribution of the forces or a sufficient elasticity of the fixing.

An object of the present invention is consequently to provide an elastically yieldable rail fixing device which overcomes these drawbacks while it enables the rail to be easily and reliably placed in its exact position.

According to the invention, there is provided an elastically yieldable device for fixing a rail on a support comprising a spring which is rendered rigid with the support at one of the ends of the spring and is curved in the direction of the rail, the branch of the spring extending toward the rail having a length less than the distance between the curved portion of the spring and the flange of the rail and acting on an intermediate member which bears on the flange, wherein the spring has a thickness which gradually decreases in the direction of the rail, and a swing block which is highly asymmetrical bears at one end on the flange of the rail and at its opposite end on the support and which is clamped by the thin end of the spring at a points which is in the vicinity of the edge of the flange of the rail but outside the flange and spaced from the bearing point on the support, the lever arm between the point of application of the clamping force by the thin end of the spring and the bearing point on the flange of the rail being thus distinctly shorter than the other lever arm.

According to a preferred embodiment, the swing block has, in its upper part, a curved surface which has a shape corresponding to that of the thin end portion of the spring so that these two members can pivot relative to each other about a horizontal axis when the rail moves. The risks of premature and dangerous wear are thus practically eliminated.

The ensuing description of embodiments, given solely by way of examples and shown in the accompanying drawings, will bring out the advantages and features of the invention.

In the drawing:

FIG. 1 is a sectional view of an elastically yieldable device for fixing a rail according to the invention;

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1;

FIG. 3 is a diagrammatic view illustrating a means for putting a spring under tension according to the invention;

FIG. 4 is a sectional view, to an enlarged scale, of a modification of the device of FIG. 1;

FIGS. 5 and 6 are views similar to FIG. 4 of two other embodiments of the device according to the invention;

FIG. 7 is an elevational view of a device according to a modification before the rail is tightened down;

FIG. 8 is a plan view of the device of FIG. 7.

As shown in FIG. 1, the device according to the invention is adapted to fix a rail 1 on a support 2 which is, for example, a concrete tie or sleeper, an elastically yieldable sole member 4 being interposed between the rail and its support. In the embodiment illustrated in FIG. 1, the elastically yieldable sole member 4 comprises two lateral ledges 6 which are adapted to perform the function of lateral abutments for the rail so as to maintain the correct spacing of the rails of the track and the unit comprising the sole member 4 with its ledges 6 is placed in a recess in the support 2.

At a relatively large distance from the ledge 6, i.e. at a distance of about 10 cm at the minimum, there is embedded a spring steel strip 8 which comprises a branch 10 which is substantially perpendicular to the upper side of the support 2 and is embedded in the latter. Outside this support, the strip 8 is curved in the form of a swan neck so as to form a second branch or arm 12 which is substantially horizontal and extends toward the flange of the rail 1. The length of the branch 12 is however less than the distance between the branch 10 and the flange 11 of the rail so that its end is set back relative to the vertical from the vertical side 13 of this flange 11. The branch 12 moreover has a thickness which progressively decreases in the direction toward the rail 1. For example, the maximum thickness of the spring strip 8, i.e. the thickness of the embedded branch 10, may be of the order of 10 to 15 mm and its minimum thickness, i.e. the thickness of the free end portion 14 of the branch 12, is of the order of 4 to 5 mm. The spring thus has a thickness which varies as a function of the bending moment to which it is subjected and constitutes a spring having a substantially constant bending strength. Consequently, for a given weight of steel, it exerts both the maximum force and has the maximum flexibility.

The thin end portion 14 of the branch 12 bears on the upper side of a swing or compensating block 16 which bears at one end 17 on the flange 11 of the rail and at its other end 18 on the support 2 in the vicinity of the

embedded branch 10 of the spring. The bearing points 17 and 18 are located on each side of the vertical from the point 15 of application on the block 16 of the clamping force F exerted by the spring 8, at distances from said vertical which are distinctly different. Consequently, the lever arm 1_1 between the bearing point on the flange of the rail and the point of application of the clamping force exerted by the spring is much shorter (about one quarter and even less) than the lever arm 1_2 between the same point of application 15 of the clamping force and the bearing point on the support of the rail so that there is good distribution of the clamping force on these two parts.

Preferably, the thin end portion 14 of the spring 8 is curved in such manner as to have a substantially part-cylindrical shape whereas the swing block 16 has a corresponding curved shape. In the embodiment illustrated in FIG. 1, the thin end portion 14 has a concavity facing the exterior and the block 16 has a recess having a similar radius. The block 16 is thus both guided and maintained relative to the spring 8 in the direction perpendicular to the rail which prevents it from turning relative to the rail, whereas it is capable of pivoting slightly relative to the end portion 14 and thus distributing the clamping force F on a sufficient area.

Preferably, the part-cylindrical end portion 18 of the spring 8 has a deformation or boss 20 (FIG. 2) which cooperates with a corresponding cavity formed in the part-cylindrical recess of the block 16 so as to prevent this sliding in a direction parallel to the rail 1.

The swing block 16 may be made from any suitable material and in particular from metal. However, when it is desirable to elastically insulate the spring 8 from the rail 1, this block is made from an elastically insulating material. Its thickness may then be sufficiently great to permit constructing it from a sheet material with as little use as possible of products derived from oil, such as resinified wood and/or plywood, or agglomerated fibres. The cooperation of the cylindrical surfaces of the block and the end portion 14 of the spring 8 enables the clamping force to be distributed over a sufficient area so that the pressure undergone by this block is compatible with such a material without necessity to reinforce it with a metal reinforcement or plate.

The number of component parts of the fixing device, and more particular of the metal parts, is thus limited and this reduces the total weight of the device and of course its cost.

The rail may be, moreover, exactly placed in position with no problem. Indeed, when mounting the rail, the spring 8 is first embedded in the tie 2 and the elasticity of the branch 12 tends to move it toward this tie 2 so that the cylindrical end portion 14 assumes the position shown in dot-dash lines in FIG. 1, i.e. a position close to the tie and the lateral ledge 6 of the elastically yieldable sole member 4 but short of the inner face of this lateral ledge. The rail 1 is then placed in position on the sole member 4 between the two lateral ledges 6 which guide it and adjust its position. The end portion 14 of the spring 8 must then be raised so as to permit the introduction of the swing block 16 by translation thereof in a direction parallel to the rail 1, then this end portion is made to bear on the block 16 in the position shown in full lines in FIG. 1. It will be clear that the elastic deformation of the spring 8 resulting from the passage of the end portion 14 from the initial position of rest indicated in dot-dash lines to the position of use indicated in full lines, determines the value of the clamping force exerted by this spring. The thickness and the shape of the swing block 16 are thus chosen in accordance with the desired clamping force.

The raising of the thin cylindrical portion 14 of the spring 8 so as to introduce the block 16 may be achieved by means of the block itself by giving to the recess 21 receiving the cylindrical end portion 14 inclined generatrices as shown in FIG. 2. In this case, this cylindrical end portion 14 has itself generatrices inclined at the same angle. This inclination is for example of the order of 10%. The swing block 16 is then introduced under the end portion 14 in the manner of a wedge and progressively raises the spring as it is shifted in a direction parallel to the rail. When the bars 20 enters the corresponding cavity in the recess 21 of the block 16, the spring has been raised to the desired extent for producing the desired clamping force.

It will be understood that, in some cases, it may be considered preferable to raise the spring by means of an outside machine placed on the rail or by means of a lever or a sufficiently long crow-bar, such as that shown at 22 in FIG. 3. The thin end portion of the spring 8 is then folded so as to form a hook 24 in which the end of the lever 22 may be fitted. This lever bears on the thickest end portion 25 of the branch 12 of the spring and raises this hook to an extent slightly greater than that required for obtaining the desired clamping force. The travel of the lever 22 may be limited, for example, by an abutment 26 which bears against the support 2 so as to avoid an excessive deformation of the spring 8. The block 6 is then easily introduced under the hook 24 which is released and allowed to bear on the block in the same way as the end portion 14.

Whatever the arrangement chosen for raising the end portion of the spring 8 and putting it under stress, the fixing device permits a precise and exact positioning of the rail next to the spring and then an effective clamping of this rail through the swing block 16.

It will be understood that this fixing device may be used just as effectively when the elastically yieldable sole member on which the rail bears does not have lateral ledges and in particular in the case where the support is formed by a steel sole member or plate, or by a flat metal tie or sleeper as shown in FIG. 4. In this case, the rail 1 is placed on a flat insulating sole member 28 which is placed on the surface of the flat support 30. Instead of being embedded in the concrete, the fixing branch of the spring 31 is maintained against the upper surface of the support by means of rivets or countersunk-head screws 32 and a metal counter plate 34 which maintain the branch 31 closely clamped against the support 30. A plate or slab 36, bearing at one end against the edge 13 of the flange of the rail 1 and at its other end against the edge 33 of the branch 31 of the spring, laterally maintains the rail in position. The length of this plate 36 measured in the direction perpendicular to the rail, not only exceeds the distance between the end edge 33 of the branch 31 and the thin end portion 14 of the spring, but is sufficient to ensure that the plate 36 can perform substantially the function of a connecting rod following the small vertical movements of the flange of the rail without any relative friction and wear, the bearing point on the end edge 33 of the spring then performing the function of a semi-articulation. In this embodiment, the swing block 16 bears at one end against the flange of the rail and at its opposite end against the counterplate 34 which is rigid with the support 30. The

plate 36 is of a material which has a good resistance to compression and preferably electrically insulating.

A plate for laterally maintaining the rail may also be employed with a spring 8 embedded in a support of concrete as shown in FIG. 5. In the embodiment shown in this FIG. 5, the rail 1 is placed on a flat elastically yieldable sole member 38 which covers a part of the upper surface of the concrete support or tie 2. A lateral abutment plate 40 bears at one end, on one hand against the fixing branch 10 of the spring 8, and, on the other hand, against the concrete support 2 itself, and bears at its opposite end against the elastically yieldable sole member 38. This plate 40 determines the exact placement of the flange of the rail 1 and enables the rail to be installed before the swing block 16 is placed in position. However it may be in one piece with this swing block, which has the advantage of simplifying the construction and the assembly of the track while imparting to the assembly an improved strength and dielectric resistance. In the latter case, it is particularly advantageous to arrange that the lower part of the swing block and abutment plate member 16, 40 have square shape, the width of the block 16 in a direction parallel to the longitudinal axis of the rail being equal to the length of the plate 40, i.e. to the distance between the fixing branch 10 of the spring and the edge 13 of the rail flange. The combined member 16, 40 is then placed in position against the branch 10 which is initially perpendicular to its normal position of operation, i.e. in such manner that its thin end edge 41 is perpendicular to the branch 10 and extends from this branch to the desired position of the edge 13 of the rail flange. A cylindrical recess 42 formed in the upper surface of the block 16 in the vicinity of the end edge 41 receives the cylindrical end portion 14 of the spring 8 without raising it, i.e. in its lower position of rest, or by slightly raising it so as to hold it stationary during transport or handling.

When the rail 1 has been placed in its correct position owing to the guiding effect of the lateral face of the member 16, 40, this member is withdrawn by a translation thereof in a direction parallel to the rail and then turned through 90° about a vertical axis and re-inserted in such manner that its edge 41 is applied against the embedded branch 10 whereas its opposite end is applied against the edge of the rail flange, as shown in FIG. 5. In this position, the cylindrical end portion 14 of the spring is raised and exerts the desired clamping force.

It will be understood that the abutment of the thin edge 41 of the swing block 16 against the fixing branch 10 of the spring 8 may be replaced by an abutment against a shoulder of the support 2.

FIG. 6 shows an embodiment of this type in which a swing block 46, which also forms a lateral abutment plate, bears against a shoulder 44 of the support 2, the fixing branch 10 of the spring 8 being embedded in this support beyond this shoulder.

Likewise, the substantially cylindrical thin end portion of the spring 8 may have its concavity facing the support. Such an end portion 48 then cooperates with a corresponding surface boss 50 of the swing block 46 (FIG. 6).

According to another modification, which is particularly adapted to the fixing on a support comprising metal abutments for the rail and in particular on a metal sole of the type normally employed on wood sleepers which is provided with shoulders 60, the swing block may be installed before the rail and simply turned without being withdrawn for ensuring also automatically the stressing of the spring.

As shown in FIGS. 7 and 8, the spring 8 comprises then, in the same way as in the embodiment of FIG. 4, a fixing branch 31 which is maintained on the upper face of the sole 50 by means of a bolt or rivet 32. This rivet however has a forged head of cylindrical shape 51 projecting about the branch 31 whereas the flexible branch 12 of the spring is provided with an oblong aperture 52 permitting access to said head.

Before the mounting of the rail, a swing block 56 is introduced between the two branches of the spring 8 and disposed parallel to the direction of the rail 1 in a waiting position shown in full line in FIGS. 7 and 8. This swing block 56 comprises a longitudinal slot 55 whereby it can be fitted on the head 51 of the rivet. Further, one of its sides 53 is thinned down in the outward direction and in the direction of the rail in the illustrated waiting position and has substantially the shape of a wedge, whereas its other side carries at its thin end remote from the slot 55 a projection 54 which is forged and adjusted upwardly and preferably laterally offset (FIG. 8). In front of this projection, ie. at the offset end of the rectilinear end edge 57, the side 53 is preferably cut at 58.

When the rail has been placed in position against the abutment 60, a pressure or blows on the shoulder 54 is sufficient to turn the assembly of the swing block 56 around the head 51 in the clockwise direction as viewed in FIG. 8, so that its edge 57, offset from the slot 55, moves toward the flange 11 of the rail. In the course of this pivoting, the edge in the shape of a wedge 53 acts in the manner of a cam and progressively raises the free end 14 of the upper branch 12 of the spring 8 while the edge 57 slides along the part 11.

This spring 8 is stressed and the slot 55 passes under the flexible branch 12 in the vicinity of the curve of the spring 8. The rotation of the swing block 56 is limited to 90° by the abutment of the projection 54 against the edge of the spring 8. In this position, shown in dotted line in FIG. 8, the solid end 57 of the swing block is clamped against the flange 11 by the end 14 of the spring 8 while the end of the edge of the slot 55 bears on the support 50 through the branch 31.

In this embodiment, as in the foregoing embodiments, the clamping force F exerted by the spring has a component which is a reaction F_1 corresponding to the effective clamping force on the rail at 17, and a reaction F_2 at 18 on the support 2. It will be clear that the elastically yieldable fastening will improve with increase in the ratio between the lengths of the two lever arms of the swing block. Now, the working conditions of this block easily permit an increase in the length of the lever arm bearing on the support.

Further, the fact that the swing block can ensure the transmission to the rail of the major part of the clamping force exerted by the spring and the transmission to the support of the lateral forces exerted by the rail and possibly electric insulation of the rail from the spring, permits the construction of a fixing device having a very small number of component parts and consequently a cheap device apart from the fact that it is particularly effective and easy to place in position.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. An elastically yieldable device in combination with a rail and a support for fixing the rail on the support, said device comprising a spring which has a first branch

rigid with the support at a first end of the spring, a bent portion and a second branch which is connected to the first branch by the bent portion and extends from the bent portion towards the rail, the second branch having a thickness which progressively decreases in the direction of the rail to a thin end portion of the spring adjacent a second end of the spring opposed to said first end thereof and a length less than a distance between the curved portion of the spring and the flange of the rail, and a compensating block which bears at one end of the block on the flange of the rail and at an opposite end of the block on the support and is clamped by the thin end portion of the spring at an intermediate point of the block in the vicinity of the edge of the flange of the rail but outside the rail.

2. A device as claimed in claim 1, comprising means defining an abutment for laterally maintaining the flange of the rail relative to the support.

3. A device as claimed in claim 2, wherein the lateral abutment for maintaining the rail comprises an abutment plate having a first end in abutting relation to the flange and a second end opposed to the first end of the plate and in abutting relation to a shoulder rigid with the support, the block being placed on said plate.

4. A device as claimed in claim 3, wherein the compensating block and the abutment plate for the flange of the rail are made in a single member and the abutment part of the member has a substantially square surface.

5. A device as claimed in claim 4, wherein the compensating block has in the upper surface thereof in the vicinity of a thinnest end edge of the block a recess of substantially part-cylindrical section which substantially matches the shape of the thin end portion of the spring so as to lock said thin end portion of the spring in a position of rest of the spring.

6. A device as claimed in claim 5, wherein the compensating block comprises a central slot for fitting on a cylindrical head of the rivet for maintaining the spring, a thinned down side in the form of a wedge and a projecting shoulder on the opposite side and pivots through 90° about the head of the rivet between a waiting position parallel to the rail and an active position perpendicular to the rail, the wedge performing the function of a cam and putting the spring under stress in the course of the pivoting thereof.

7. A device as claimed in claim 1, wherein the compensating block is highly dissymetrical, the distance between the point of application of the clamping force by the thin end portion of the spring and the bearing point of the block on the flange of the rail being distinctly shorter than the distance between the point of application of the clamping force by the thin end portion of the spring and the bearing point of the block on the support.

8. A device as claimed in claim 1, 2 or 7, wherein the thin end portion of the spring has a substantially part-cylindrical curved shape and cooperates with a portion of substantially matching shape on the upper surface of the block against which block the thin end portion bears.

9. A device as claimed in claim 8, wherein the generatrices of the part-cylindrical end portion of the spring and of the matching surface of the block are inclined relative to the horizontal so that the block constitutes a wedge for raising the end portion of the spring.

10. A device as claimed in claim 9, wherein the thin end portion of the spring is curved so as to form a hook for the insertion therein of a tool for raising the thin end portion of the spring.

11. A device as claimed in claim 1, 2 or 7, wherein the first branch of the spring extends in a direction parallel to the support and clamping means clamp the first branch against the support.

12. A device as claimed in claim 1, 2 or 7, wherein the compensating block is made from an insulating material.

13. A device as claimed in claim 12, wherein the insulating material is a resin-impregnated wood.

14. A device as claimed in claim 12, wherein the insulating material comprises fibres agglomerated by a resin.

* * * * *

United States Patent [19]

Huchette et al.

[11] 3,968,958

[45] July 13, 1976

[54] COMPOSITE MATERIAL SPRINGS AND MANUFACTURE

[75] Inventors: Paul V. Huchette, Latrobe; Homer H. Hall, Jr., Vandergrift, both of Pa.

[73] Assignee: Edgewater Corporation, Oakmont, Pa.

[22] Filed: June 11, 1975

[21] Appl. No.: 585,747

Related U.S. Application Data

[60] Division of Ser. No. 310,815, Nov. 30, 1972, Pat. No. 3,900,357, which is a continuation-in-part of Ser. No. 34,117, May 4, 1970, abandoned.

[52] U.S. Cl. 267/47; 267/149

[51] Int. Cl.² F16F 1/22

[58] Field of Search..................... 267/47, 148, 149; 280/124 R, 11.13 L; 264/263; 156/185, 191, 195

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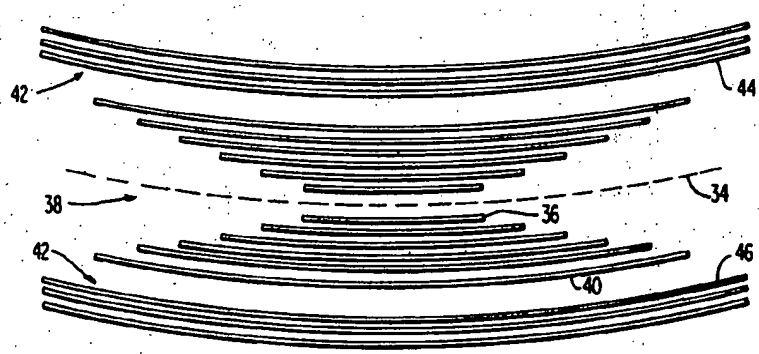
Primary Examiner—James B. Marbert

Attorney, Agent, or Firm—Shanley, O'Neil and Baker

[57] ABSTRACT

Light-weight, corrosion-resistant, elongated spring structure formed from fiber-reinforced composite material and method of manufacture in which a configuration-defining core portion is laid up from non-woven fiber plies of varying longitudinal dimension with such centrally located core portion being overlaid with a plurality of elongated plies of non-woven fibers extending between longitudinal ends of the spring structure. Transverse strength in the elongated spring structure is obtained from placement of crossply material generally contiguous to the outer surface or by helical wrapping of the longitudinally oriented plies. Included are methods for forming integral spring-mounting means and manufacture of a plurality of spring structures simultaneously.

16 Claims, 15 Drawing Figures



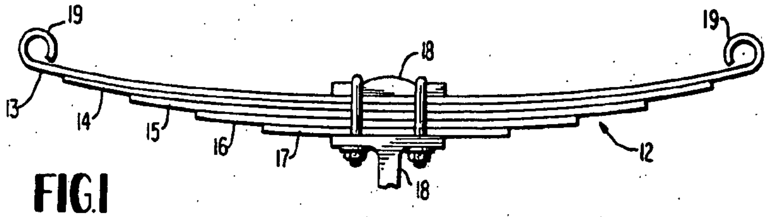


FIG.1
PRIOR ART

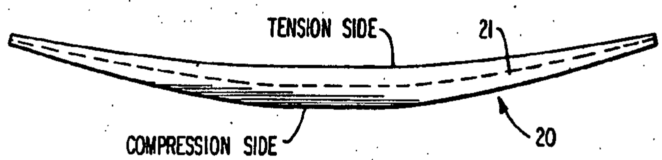


FIG2

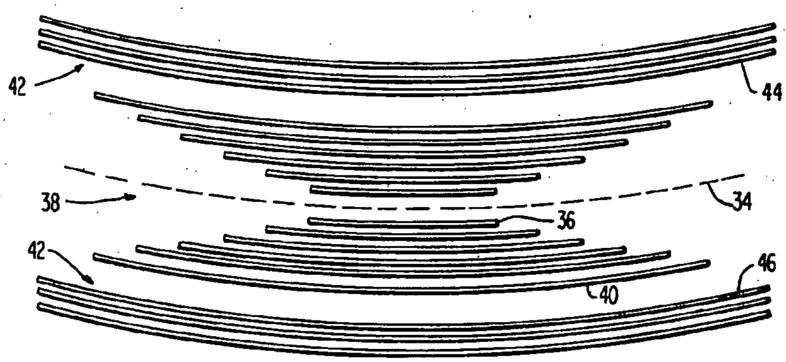


FIG.4

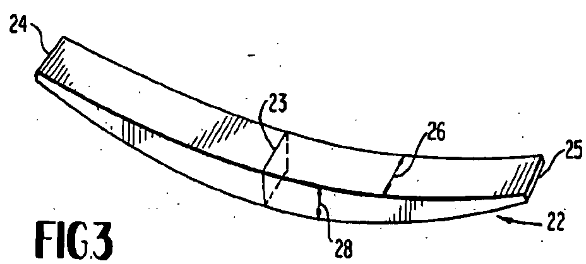
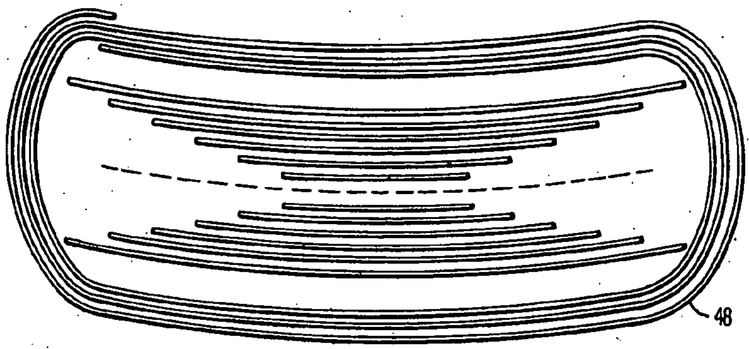


FIG.3

FIG.5



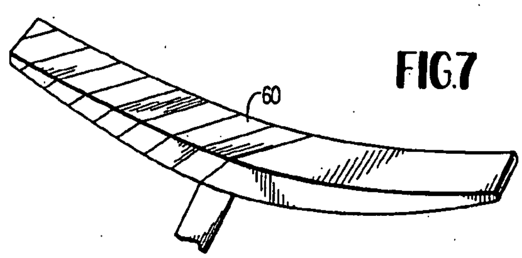


FIG.7

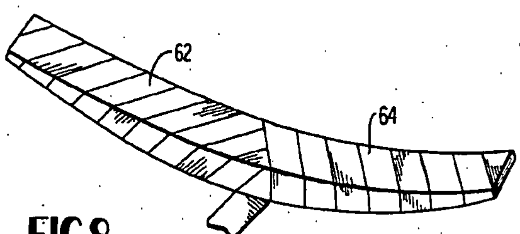


FIG.8

FIG. 6

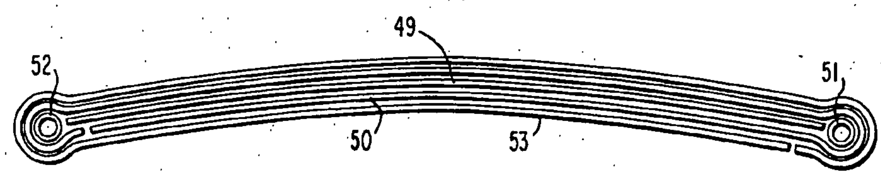


FIG. 14

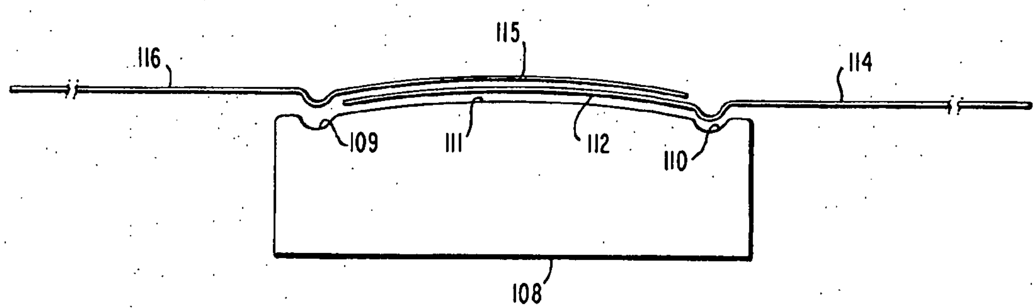
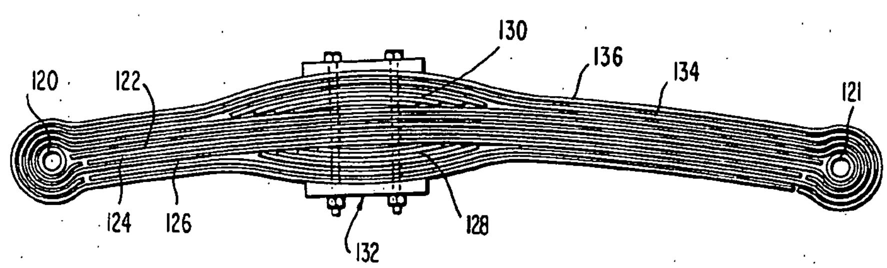


FIG. 15



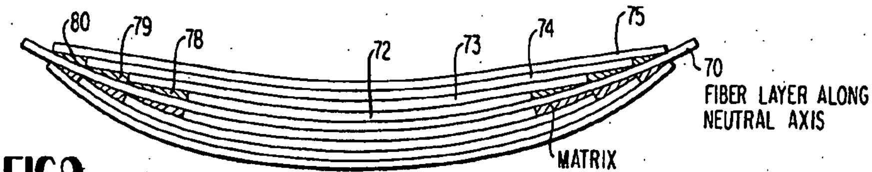
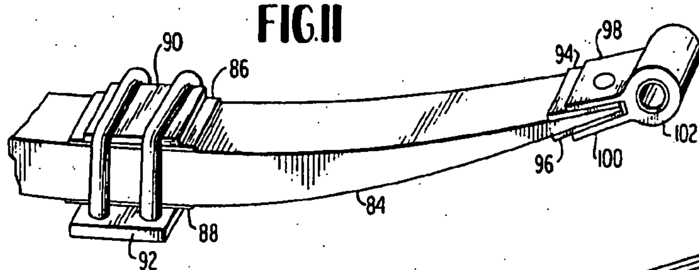


FIG.9

FIG.10

FIG.11



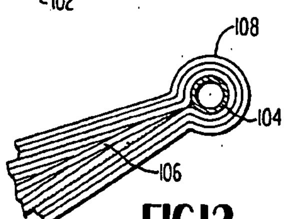


FIG.12

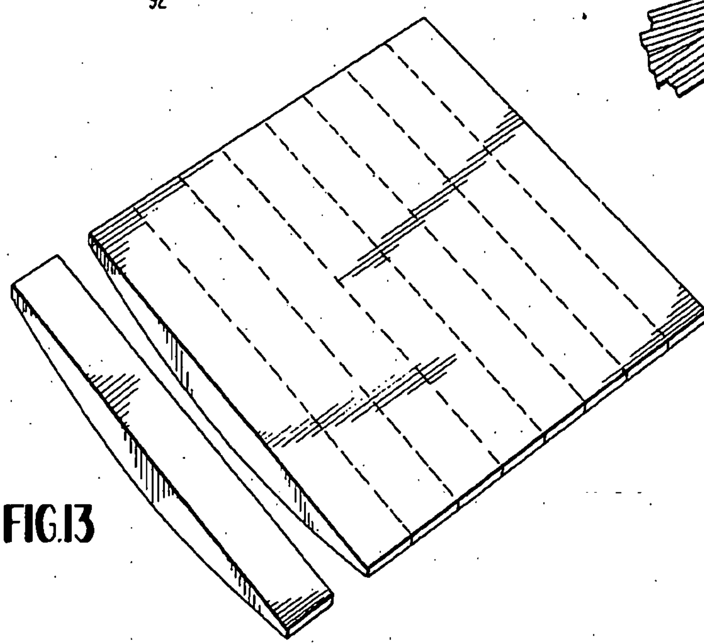


FIG.13

COMPOSITE MATERIAL SPRINGS AND MANUFACTURE

This is a division, of application Ser. No. 310,815, filed Nov. 30, 1972 now U.S. Pat. Ser. No. 3,900,357, which was a continuation-in-part application of Ser. No. 34,117, filed May 4, 1970, now abandoned.

This invention is concerned with fiber-reinforced springs.

The potential advantages of fiber-reinforced composites have been known for some time. Similarly the growing commercial need to find improved replacements for conventional metallic springs has existed for some time. However, difficulties which have been considered inherent with composite materials or shortcomings of known fabricating techniques with composites have forestalled development of fiber-reinforced springs for many uses. For example, fiber-reinforced composites have not been adopted commercially for leaf-type spring application in vehicles.

The prime objective of this invention is to provide teachings on spring configurations and methods of fabrication which overcome such earlier limitations enabling elongated, specially contoured, fiber-reinforced springs to be manufactured economically for commercial use application calling for absorption of shock or vibration at a point or points longitudinally spaced from a relatively fixed location. In environments where lightness of weight, and resistance to corrosion and fracture are factors, such as in snowmobile springs, advantages of the products of the present invention far surpass the known features of metallic springs.

In applying the concepts of the invention to vehicle springs, reliance on a plurality of leaves acting together is eliminated. This is made possible through an important concept of the invention in the fabrication of composites which places materials best able to withstand stress at locations where greatest stress occurs. Other basic contributions will be considered in describing the invention utilizing the accompanying drawings. In these drawings:

FIG. 1 is a side view of a prior art leaf spring and mounting means,

FIG. 2 is a side view of a semi-elliptical tapered spring configuration included in the present invention,

FIG. 3 is a perspective view of a semi-elliptical tapered spring configuration included in the present invention,

FIG. 4 is an expanded schematic representation of fiber plies as assembled in a preferred embodiment of the invention,

FIG. 5 is an expanded schematic representation of fiber plies as assembled on another embodiment of the invention,

FIG. 6 is an expanded schematic representation of fiber plies as assembled to form the neutral axis lay-up of an embodiment of the invention,

FIGS. 7 and 8 are perspective view of springs illustrating the helical wrapping taught by the invention,

FIG. 9 is an enlarged cross-sectional schematic view of a portion of an embodiment of the invention,

FIG. 10 is an enlarged cross-sectional schematic view of a portion of another embodiment of the invention,

FIG. 11 is a perspective view of a portion of an embodiment of the invention with non-unitary mounting means,

FIG. 12 is a schematic representation of a portion of a spring being assembled with an integral mounting means in accordance with the teachings of the invention,

FIG. 13 is a schematic representation of a step in the simultaneous production of a plurality of springs in accordance with the teachings of the invention,

FIG. 14 is an expanded schematic representation for illustrating the assembly of a spring on a male die member in accordance with the invention, and

FIG. 15 is an expanded schematic view for illustrating the lay-up of plies in one embodiment of the invention and placement of spring mounting means.

In describing the invention, glass is presented as a specific fiber in a composite material. Matrix materials, dimensions and structural relationships are presented for purposes of making a full, clear, and exact description of an embodiment of the invention in terms readily understood in the art. However, disclosure of such specifics in describing the invention does not exclude other composite materials, dimensions and structural relationships from the scope of the invention as defined by the claims.

Referring to FIG. 1, spring 12 is a conventional leaf spring in which a plurality of leaves, such as leaves 13, 14, 15, 16, and 17 are held together by clamp 18. Along with clamp 18, eyelets 19 provide for mounting of the spring in a conventional manner.

The plurality of leaves of spring 12 acting together provide the required strength and shock-absorbing facilities. This plurality of segments acting together has not been practical for most composites, especially fiber-reinforced plastic because of its poor abrasion resistance. The invention makes practicable the manufacture of a unitary spring configuration from composite material which provides the shock-absorbing facility of a plurality of leaves.

FIG. 2 shows a side view of a spring configuration 20 made practicable for composite fabrication by the teachings of the invention. Spring 20 is semi-elliptical in configuration with neutral axis 21, shown in dotted lines, located midway between the tension and compression sides of the spring.

Spring 22 of FIG. 3 is a unitary structure in accordance with the teachings of the invention. A longitudinal midpoint of center section plane 23 is located midway between longitudinal ends 24 and 25. Width dimension 26 is measured in a plane transverse to the longitudinal axis, as shown. Width 26 is uniform throughout the length of spring 22. Thickness dimension 28, measured in a similar transverse plane in the direction shown, varies throughout the length of spring 22.

Cross-sectional area in a plane transverse to the longitudinal axis is greatest at the midpoint 23 and diminishes symmetrically in both directions in approaching the longitudinal ends 24 and 25. The result is a semi-elliptical spring which is symmetrically tapered in approaching its longitudinal ends from a maximum cross-sectional dimension at its longitudinal midpoint. A full elliptical spring may be assembled by use of two semi-elliptical springs and, a quarter elliptical by use of one-half of such a spring. Non-symmetrical taper and rectilinear surfaces on the tension and compression side can also be fabricated within the inventive teachings.

End products such as the springs of FIGS. 2 and 3 are solid and unitary. The methods of fabrication with composite materials taught by the invention enable

solid unitary springs to withstand differing stresses at differing locations throughout the structure.

The invention teaches use of non-woven, fine filaments or fibers as the stress absorbers. The fibers are held together in side-by-side relationship by a suitable matrix material and extend in substantially the same direction in a single ply. Such fiber plies, in either strip or sheet form, are utilized in the invention. Several plies, pre-impregnated with a matrix material, can be joined to form a multi-ply lamination. A suitable composite material is fiber glass pre-impregnated, or held, in a polymer such as an uncured epoxy. This composite material can be obtained commercially, for example, from the 3M Company, St. Paul, Minnesota, under the trademark Scotchply tape, Type 1002. For purposes of the invention, continuous strip and sheet-like raw materials are preferred. Preferred combinations of single ply and multi-ply laminations are covered in more detail in subsequent description.

In assembly a centrally located core for a spring such as that shown in FIG. 3, plies are cut to predetermined varying lengths. FIG. 4 illustrates schematically assemblage of this embodiment of the invention. Dotted line **34** represents the longitudinal axis, i.e., the neutral axis of the spring. Plies, of shortest longitudinal length, such as **36**, are placed in contiguous relationship to the neutral axis **34**.

For long life in high-frequency cyclically-stressed spring applications, elongated plies are placed along the neutral axis to transfer the stress to the ends of the spring. For substantially static load spring applications, fatigue life is satisfactory without such neutral axis elongated plies. Plies of increasing length are added as a centrally located core **38** is built up in both directions. Outermost ply **40** of the core would have the maximum length of the center core plies which ply **36** would have the minimum length.

The plies of the centrally located core are placed on overlaying relationship longitudinally as shown. The centrally located core **38** is surrounded by peripheral portion **42**. In the embodiment shown in FIG. **4**, this peripheral portion is built up from a plurality of substantially equal length plies, such as **44, 46,** extending between longitudinal ends of the configuration.

The fibers in the individual plies of the centrally located core and peripheral portions are unidirectionally oriented and non-woven. However the direction of orientation of the fibers in certain plies can differ from that in remaining plies as will be considered in more detail later.

In accordance with the invention the peripheral portion of the contoured spring can also be built up by spiral wrapping as shown in FIG. **5**. This spiral wrapping includes continuous-length material forming a plurality of layers **48**. With the fiber glass-polymer composite material being considered, the assemblage is laid up to the curvature desired and then pressure and heat treated to form a solid unitary structure. The matrix material bonds the fibers together so as to transmit stress from one fiber to another.

Considering fabrication in more detail, after determination of the desired longitudinal midpoint thickness, the thickness of the centrally located core portion can be determined. The average cured thickness of one lamination of fibers is readily available; the thickness of a representative pre-impregnated sample of fiber glass in a polymer such as epoxy is approximately 0.010 inch. From the individual ply thickness, the number of plies required in the centrally located core can be determined.

Lay-up of the centrally located core can begin at the longest lamination required, on either the tension or compression side of the spring, and proceed with decreasing length plies until the shortest ply lies on or near the neutral axis. The remaining side of the center core of a semi-elliptical spring can then be laid up by overlays of increasing length plies symmetrically disposed as shown in FIGS. **4** and **5**.

For spring function and fatigue-life purposes, it is preferable to have all fibers oriented in the longitudinal direction. This carries out one concept of the invention of placing longer fibers along directions of greater stress. However, with presently available matrix material, the strength of the composite comes from the fibers. Therefore, provision is made for adding transverse strength to the spring for purposes of avoiding longitudinal splitting of the unitary structure. One method taught for imparting transverse strength is placement of crossply material contiguous to the outer surfaces of the spring. As a representative teaching, one crossply may be utilized immediately subsurface each outer surface layer of fibers which extend longitudinally on the tension and compression sides. Pre-impregnated tape to required specifications of a longitudinally directed ply overlaying a crossply can be obtained or pre-assembled. Crossplies spaced internally of the crossply contiguous to each surface can be used in static load applications but should not ordinarily be used in high-frequency cyclically-stressed application where long fatigue life is a requirement.

A basic concept of the invention is carried out by placement of the plies with the longer fibers in locations of greater stress. The stress on either the tension or compression side of the neutral axis increases with the distance from the neutral axis. With the assembly described, the longest longitudinally directed fibers are located at the greatest distance from the neutral axis. Another distinct advantage of the assembly taught is that the longitudinal ends of the varying-length centrally located core plies, when assembled, all lie along the neutral axis of the spring. With the longitudinal ends of these plies at the neutral axis, and therefore at a location of zero bending stress, the bending strength of the structure is enhanced. The possibility of delamination or breakage at an internally terminated end from repeated deflection is substantially eliminated. To enhance these properties elongated plies are placed along the neutral axis with the ends of the core plies contacting the neutral axis plies. This transfers internal stresses in the ends of the spring.

FIG. **6** shows, in expanded form, the neutral axis lay-up of such an embodiment in a spring with integral support bushings at each longitudinal end. Ply **49** lies along the neutral axis between the two bushings. Ply **50**, next adjacent to neutral axis ply **49** starts on the tension side of the spring at bushing **50**, extends along the tension side, wraps around bushing **51**, returns along the compression side of the spring, and around bushing **52** to return to its starting point. The next adjacent ply **53** starts at bushing **51** extends across the tension side of the spring, wraps around bushing **52** and returns along the compression side to its starting point.

The core plies are layed up with their longitudinal ends contiguous to the neutral axis in order to transfer stresses to the ends of the spring along such neutral axis.

As part of the lay-up of the peripheral portion of a static load spring, e.g. the springs shown in FIGS. 4 and 5, a crossply wrap can be used as the first ply over the centrally located core portion. Such a crossply contributes to the transverse strength of the core since the fibers are directed in line with any force attempting to separate the spring transversely, i.e. to help avoid a split running longitudinally of the spring.

The longitudinally directed fibers of the peripheral portion plies are then placed in a series of plies, individual wraps, or continuous spiral wrap until the required number of laminations are obtained. A crossply may be inserted at predetermined intervals during this build-up for example, one crossply for about 15 plies of longitudinally directed fiber plies in static load spring applications where additional transverse strength may be required.

However, for spring functioning purposes, it is preferred to have all fibers of the centrally located core portion and the peripheral portion of the spring structure longitudinally oriented. This orientation places the fibers in a direction to counteract the major stresses during deflection. An important contribution of the invention is a fabrication method which permits this orientation and eliminates crossply material, other than contiguous to an outer surface, while maintaining transverse strength to meet requirements.

In carrying out this latter concept, fibers in the centrally located core portion and peripheral portion of the spring structure are laid up unidirectionally between longitudinal ends. In one embodiment, the resultant configuration is then helically wrapped with an elongated, relatively narrow strip of the composite material. The fibers in this strip are unidirectionally oriented, before lay-up, in the direction of its length. The helical wrapping is angled in both the lateral and longitudinal directions of the spring as shown in FIG. 7. The fibers in helical wrap 60 are directed across and cover both the width and thickness surfaces of the configuration between its longitudinal ends. The wraps are in side-by-side relationship and, preferably, do not overlap, along their side edges.

In the helically wrapped embodiment of FIG. 8, the first helical ply 62 is wrapped in a "left hand" helix from left to right end of the spring. An additional helically wound ply 64 is wrapped in a "right hand" helix from right to left end of the spring over the first helical wrap.

In practice the helical wrapping can be carried out after setting, or curing, or preliminary curing, of the basic configuration. The spring with the helical wrap or wraps is then cured to form a unitary structure. The additional curing of the centrally located core and peripheral portions of the spring is found to have a salutory effect on the strength properties when this double curing step approach is utilized.

To review the assembly, after determining the desired dimensions including longitudinal end and longitudinal midpoint thicknesses, the centrally located core section is devised to provide desired spring contour. The centrally located core section provides for differences of thicknesses along the longitudinal direction of the spring and forms the desired contour for the spring. The peripheral portion of the spring is built-up to be in longitudinal overlying relationship to the centrally located core portion. The cured thickness of each ply is known so that the number of plies in the centrally located portion and in the peripheral portion can be readily determined.

A basic contribution of the invention is the unique coaction in the placement of fibers so as to withstand differing stresses in the structure and achieve desired configuration. Longer fibers are placed in the areas of higher stress and shorter fibers can be placed in the areas of lower stress to obtain both desired strength and configuration.

The assembled plies are treated in a suitable mold to form a unitary structure. The glass fibers of the present embodiment are held together by a thermosetting material which solidifies to a permanent hardness after being held at the prescribed temperature for a predetermined period. A spring assembled from the pre-impregnated tape comprising fiber glass held in a matrix of epoxy is heated to a temperature of above about 150°C. at 50 pounds per square inch pressure.

In practice the plies are laid up in conjunction with a mold of desired semi-elliptical configuration which has been coated with a parting agent such as silicone compound, e.g., Dow-Corning's DC20. The mold and plies are heated for a short time at a temperature below curing temperature, approximately 280°. This gel-time usually extends over approximately 3 to 5 minutes and is carried out with minimal pressure on the plies. The mold is then removed from the furnace and pressure to about 50 psi is gradually applied. The structure is then cured at a temperature between about 150°C. to 175°C. for a period of time dependent on the size of the spring. A one-inch wide, ¾ inch thick, 24 inch long spring cures in about 45 minutes. Larger springs require longer time at temperature. Other curing cycles of reduced temperature over longer periods of time after initial high temperature and pressure treatments are available.

A solid unitary structure is thus formed in which the plastic material transmit the stress from one fiber to another. The high strength fiber glass, which is ordinarily brittle, reacts in a non-brittle fashion because of the matrix. One of the advantages of this type of spring as compared to a conventional metallic spring is that, if failure due to working stresses does occur, there is a progressive failure with fibers breaking individually over an extended period of continued satisfactory performance rather than a complete failure as experienced with conventional metallic springs. In other words, a fiber glass spring will fail a fiber at a time so that any break in the fiber glass reinforced spring will occur gradually, while continuing to function, rather than all at once as occurs in steel springs.

Fibers of differing moduli of elasticity can be utilized to fabricate a spring of desired properties. Fiber glass has a lower modulus of elasticity than steel whereas graphite fibers or boron fibers have a higher modulus of elasticity. A typical polymer for bonding of the glass fibers is epoxy. Other polymers include polyesters and polyamides. Because of the brittle nature of glass, filaments which make up the fiber glass strands do not exceed 0.001 inch diameter. Graphite filaments of similar or smaller diameters, e.g. 6.6 microns can be used.

In a typical lay-up of fiber glass-epoxy plies for a semi-elliptical spring of eighteen-inch length and substantially 0.60 inch midpoint thickness, the centrally located shortest core plies at the neutral axis are approximately 3 inches in length. The plies increase in length from the shortest gradually to slightly less than eighteen

inches in length at the outside surfaces of the centrally located core. The peripheral portion plies, individual equal length plies or spiral wraps, extend over the full length of the spring. At the longitudinal midpoint a total of about thirty plies make up the centrally located core. The peripheral portion is made up of about 30 plies of material equally distributed on the compression and tension side of the spring.

In a preferred embodiment of the invention for long fatigue life in cyclically stressed spring applications an elongated ply, or plies, extending over the full length of the spring, is placed along the neutral axis as described above in relation to FIG. 6. The advantages of utilizing an elongated ply of fibers along the neutral axis of the spring are shown in the enlarged representational cross-sectional view of FIG. 9. Ply **70** has its fibers oriented in a longitudinal direction and lies along the neutral axis of the spring. The centrally located core plies **72, 73, 74,** and **75** are placed in overlying relationship with the shortest ply being contiguous to the neutral axis as shown. Similarly varying length plies are placed on the opposite side of the neutral axis ply **70** extending towards the compression side of the spring. The longitudinal ends of each of the centrally located core plies contact the neutral axis ply. It will be seen that the matrix material **78, 79,** and **80** between ends of the centrally located core plies at the neutral axis is of small concentration and, is distributed to a greater degree than the concentrations of matrix material **81** and **82** shown in the embodiment of FIG. 10.

In FIG. 10 the centrally located core plies are laid up without an elongated ply along the neutral axis, an embodiment which can be used satisfactorily for substantially static load applications.

In assembling a spring of the type shown in FIG. 9 having an 18-inch length, semi-elliptical configuration, one-inch width and a total longitudinal midpoint thickness of substantially .620 inch, the dimensions can be built up as follows: An elongated ply, with fibers oriented longitudinally, is located along the neutral axis of the core. The central core portion is built-up by adding plies in order of 3, 6, 7, 10, 11, 12, 12.5, 13, 14, 15, 16, 16.5, and 17.85 inches in length. These plies are laid-up symmetrically with the minimum length ply being contiguous to the neutral axis ply and the overlying plies being of increasing length in both directions toward the compression and tension sides of the spring. Over the centrally located core portion fifteen elongated plies approximately 18 inches in length are laid-up on the tension and compression sides.

The configuration defined by the central core portion and the peripheral portion is, in accordance with the teachings of the invention, assembled on a portion of a mold of desired configuration. The mold is coated with a parting compound and preheated as described earlier. A fiber glass-epoxy spring is cured at a temperature of about 165°C. and 50 pounds per square inch pressure.

The combination center core portion and peripheral portion spring configuration after precuring or setting, is helically wrapped with two plies as shown in FIG. 8 with the first ply extending in a left hand helix from the left end of the spring and the second ply extending in a right hand helix from the right end of the longitudinal end of the spring. The spring is then replaced in a mold and the entire combination cured under heat and pressure to form a solid unitary structure.

The helical windings are placed in side-by-side relationship without overlaps so that a smooth surface spring results. The advantages of using elongated plies in the peripheral portion of the spring in place of spiral wrapping is that a sharp angled bend of the spiral wrapping at longitudinal ends of the spring is avoided.

The above-described spring was tested as follows: In a fatigue-life testing machine the spring was deflected through full deflection for one million cycles. No evidence of delamination, fraying or spring failure occurred. The spring was then load-tested at 500 pounds and returned to the fatigue-life tester. The spring was cycled through full deflection for an additional two million cycles before any appreciable loss of load-carrying capability occurred. Slight fraying or delamination occurred over an extended period of time with the decrease in load-carrying capacity. The spring was still performing at 10,000,000 cycles.

It should be noted that full-deflection cycling is an unusual and severe form of testing and, was applied to accelerate the program so as to obtain data in the shortest possible time. Metallic springs with the same flexibility cannot be cycled through more than approximately 400,000 cycles of full deflection without failing due to fatigue.

FIG. 11 shows typical mounting means for a fiber-reinforced spring **84** connected at a longitudinal end and the longitudinal midpoint. At each location a layer of low-friction, abrasion-resistant material is used. Suitable abrasion-resistant materials include poly-urethane, Teflon (DuPont), Nylatron (Polymer Corporation), nylons, and polyamides. At the longitudinal midpoint abrasion-resistant layers **86** and **88** are placed between clamps **90** and **92.** At the longitudinal end, abrasion-resistant layers **94, 96** are placed between the flanges **98, 100** of bearing housing **102.**

FIG. 12 shows schematically the lay-up used with a bushing or eyelet for a bearing formed integrally with the spring. A mandrel **104** is supported at the end of centrally located core portion **106.** Mandrel **104** is coated with a parting compound. Spiral wrappings of the peripheral portion **108** are wrapped around the mandrel **104.** The spring is cured with the mandrel **104** in place. After curing, the aperture formed by mandrel **104** receives a bearing for subsequent mounting of the spring. The bearing can be coated with an abrasion-resistant material on its outer surface or can be formed from a material such as Nylatron, available through the Polymer Corporation, Reading, Pennsylvania.

In the embodiment of FIG. 12, fibers of the peripheral portion plies are longitudinally oriented. The spiral wrappings make the mounting means a part of the unitary structure with the fibers longitudinally oriented in the direction in which stress occurs.

Adaptability to mass production is one of the advantages of the fabrication methods taught. Using sheet-like plies a plurality of springs can be assembled and cured simultaneously. The lay-up of the sheet-like plies follows the earlier description of individual springs with the longitudinal direction of lay-up being coincident with the longitudinal direction for the springs. Side views of the assemblies of FIGS. **4, 5, 6, 9, 10, 12, 14,** and **15** are identical for individual strip and sheet-like plies.

After assembly of the center core portion and peripheral portion from sheet-like plies, the composite is cured. As shown in FIG. **13,** the assembly is then sliced longitudinally into individual springs of desired width.

Thus a plurality of identical spring or springs of varying width can be produced simultaneously. The cured springs can be polished to smooth any of the results of slicing.

If an embodiment calling for use of helical wrapping is made from sheet-like plies, after slicing, the simultaneously produced individual springs can be helically wrapped and cured as described earlier.

Preferably however individual spring lay-ups or multiple-spring lay-ups use a crossply in the penultimate fiber layer to the surface layer. This provides sufficient transverse strength for most applications and eliminates crossplies in locations where shear-plane delamination is likely to occur under high frequency stressing.

Lay-up of the outer wraps of such a preferred embodiment for integral bushing assembly is shown in FIG. 14. Lay-up is preferably made on a mold to impart the desired contour from the outset. Male die member **108** includes contour indentations **109** and **110** for reception of bushing contours during assembly and, during compressing and curing. Surface **111** of the male die member contacts the tension side of the spring contour. Outer wrap **112** is laid along this contour with an overhang portion **114** to provide the outer wrap ply on the compression side. The length of this outer ply is selected to make a full wrap, i.e. extending the full length along the tension and compression sides and around the bushings.

This outer wrap ply can include two fiber layers laminated together. In the outermost laminate the fibers extend longitudinally between ends of the spring. The next inner laminate can comprise crossply fibers, i.e. at an angle, such as 90°, to the longitudinal direction. In that way, the crossply layer is contiguous to the surface on both the tension and compression sides of the spring. The number of plies in the outer wrap portion is selected based on the spring application and desired spring dimensions.

Note that overlay for the compression side exists on alternate longitudinal ends. As shown in FIG. 14 the second ply **115** includes compression-side overlay **116** on the left side of the spring. In this way, the juncture lines for longitudinal ends of these elongated wraps occur in alternate relationship at opposite longitudinal ends of the spring structure.

Assembly of the elongated spring of FIG. 14 on the curvilinearly contoured die member is an important aspect of the invention for purposes of smooth lay-up without crimping or bending of the fibers and to avoid air pockets, problems which can occur when attempting to lay up a spring on a planar surface and then placing it on a curved mold for curing.

After the outer wraps are positioned as shown in FIG. 14 the tension side core portion is laid up with progressive shorter lengths in approaching the neutral axis. The number and length are selected dependent on desired spring characteristics and dimensions.

The elongated plies along and contiguous to the neutral axis, of the type shown in FIG. 6, are then laid up. In practice the plies are laid up with overhang portions of the wraps extending outside the die contour. The neutral axis ply is placed and then the bushings are positioned. The wraps contiguous to the neutral axis are then wound around the bushings with juncture lines occurring alternately at opposite longitudinal ends as considered in relation in FIG. 6.

After the bushings have been wrapped with the elongated plies contiguous to the neutral axis, the core plies on the compression side are laid up with shortest ply innermost and of progressively increasing length in approaching the compression side.

In this manner longitudinal ends of the core plies contact the elongated plies contiguous to or at the neutral axis and transfer internal stresses to the longitudinal ends of the spring.

After the compression side core plies are in place, the overhang portion of the outer wraps are placed on the compression side and, in this step, are wrapped around the bushings.

An expanded view in cross section of a simplified version of this embodiment lay-up, in accordance with the instructions relating to FIGS. 6 and 14 above, is shown in FIG. 15. In this embodiment bushings **120** and **121** are located at opposite longitudinal ends of the spring structure. Neutral axis ply **122** extends along the neutral axis between these bushings. Plies **124** and **125** are wrapped around the bushing and located contiguous to the netural axis. Plies of varying length form the tension side core portion **128** of the central core. On the compression side, varying length plies form the compression side portion **130** of the central core.

Note that the longitudinal ends of the varying length plies contact the elongated plies forming part of or contiguous to the neutral axis. Also note that in this embodiment the central core plies are not located equidistantly from the bushings. Their location along the longitudinal axis is dependent upon physical requirements of the spring; in many uses, for example in some snowmobile uses, one leg of the spring can be longer than the remaining leg. The central core plies therefore, in addition to imparting desired configuration, also establish a location for the spring clamping mechanism shown schematically at **132**.

The peripheral portion of the spring structure of FIG. 15 comprises a plurality of wrap-around plies such as **134**, **136** contiguous to the outer surface. One of the outer plies comprises crossply fibers in order to introduce transverse strength.

It should also be noted that the juncture lines for wrap-around plies occur alternately at opposite longitudinal ends of the strip.

While a simplified embodiment is shown in FIG. 15, it should be understood that the number of plies in the neutral axis portion, core portion, and peripheral portion can vary widely dependent on desired characteristics and dimensions. In a typical snowmobile ski having overall dimensions of 28.75 inches length, 2.0 inches width, and 0.63 inches thickness along the central load line, nine wrap-around plies are used in the peripheral portion, twenty-one plies are used in each core portion on opposite sides of the neutral axis, and two wrap-around plies are used at the neutral axis. The longitudinal length of the wrap-around plies varies slightly, increasing as outer plies are reached, to allow for the added circumference around the bushings due to interior wrappings. Essentially these wrap-around plies are elongated plies covering two full lengths of the elliptical surface of the spring structure and varying in length to allow for the changing dimension around the bushings and along the outer surface as the spring is built up.

Ordinarily this assembly would be made in sheet material and after curing would be cut longitudinally to form multiple individual springs from two to twenty or more.

In spring applications calling for a free end with a bushing at the remaining end, tthe wrap-around plies would wrap around the bushing and ends of each ply would meet at the free end.

Specific embodiments of the invention have been described in disclosing various contributions made by the invention. The concepts taught can be utilized in arriving at other embodiments without departing from the scope of the invention as defined in the following claims.

What is claimed is:

1. An elongated fiber-reinforced composite spring having a tension side, a compression side, a neutral axis extending between its longitudinal ends, and a varying cross-sectional area as measured in a plane perpendicular to the neutral axis, with the cross-sectional area diminishing in approaching at least one of the longitudinal ends of the spring providing a tapered configuration, such spring comprising

a neutral axis portion, a centrally located core portion, and a peripheral portion,

the neutral axis portion comprising at least one elongated ply comprising solely non-woven fibers in the side-by-side, longitudinally-oriented, unidirectional relationship extending along the neutral axis between longitudinal ends of such spring,

the centrally located core portion comprising a plurality of varying length plies of solely non-woven fibers, such fibers being in side-by-side, longitudinally-oriented, unidirectional relationship in each ply, such plies being of varying length dimension in the longitudinal direction of such spring and oriented longitudinally in overlying relationship with shorter length plies of the varying-length plies being centrally located contiguous to the neutral axis and plies of progressively increasing length being located outwardly from such neutral axis in the direction of both the tension and compression sides of such spring,

the peripheral portion comprising a plurality of elongated full-length plies comprising solely non-woven fibers, such fibers being in side-by-side, longitudinally-oriented, unidirectional relationship in each ply, with such elongated full-length plies extending between longitudinal ends of such spring in overlying relationship to the neutral axis portion and the centrally located core portion,

such fibers in the neutral axis portion, centrally located core portion, and peripheral portion being bonded together in a matrix material forming a unitary structure.

2. The elongated unitary composite spring structure of claim 1 having a semi-elliptical configuration with the maximum cross-sectional area in a plane perpendicular to the neutral axis being located between longitudinal ends of the spring with the cross-sectional area diminishing in approaching each longitudinal end.

3. The elongated unitary composite spring structure of claim 2 in which such maximum cross-sectional area is located at the longitudinal midpoint of such elongated spring structure.

4. The elongated unitary composite spring structure of claim 1 in which the centrally located core portion is symmetrical with respect to the neutral axis.

5. The elongated unitary composite spring structure of claim 2 in which the tension and compression sides define curvilinear surfaces and the neutral axis is disposed substantially midway between such surfaces.

6. The elongated unitary composite spring structure of claim 2 in which longitudinal ends of the varying length plies comprising the centrally located core portion contact the neutral axis portion of such spring structure.

7. The elongated unitary composite spring structure of claim 2 in which the neutral axis portion comprises a plurality of elongated plies comprising solely non-woven fibers in side-by-side, longitudinally oriented unidirectional relationship extending along the neutral axis between longitudinal ends of the elongated spring and in which at least one of such elongated neutral axis plies circumscribes eyelet means at such longitudinal end of such spring structure.

8. The elongated unitary composite spring structure of claim 2 in which such plurality of elongated full-length plies of the peripheral portion have a length at least twice the length of the elongated spring structure and with such elongated full-length plies being located in spiral wrap-around relationship to the neutral axis portion and the centrally located core portion of such spring structure.

9. The elongated unitary composite spring structure of claim 1 in which at least one of the elongated plies forming the peripheral portion is located contiguous to the outer surface thereof and includes fibers oriented in angled relationship to the longitudinal direction of such spring structure.

10. The elongated unitary composite spring structure of claim 8 further including eyelet means located at at least one longitudinal end of the elongated spring with at least one of the elongated full-length plies of such peripheral portion being wrapped about such eyelet means.

11. The elongated unitary composite spring structure of claim 2 further including

at least one external ply of solely non-woven, longitudinally-oriented, unidirectional fibers covering the configuration defined by the neutral axis portion, centrally located core portion, and peripheral portion, such external ply being of extended length and relatively narrow width and being wound helically in angled relationship to the neutral axis in a continuous manner about such configuration between its longitudinal ends,

the fibers of such helically wound ply being bonded together and bonded to the remainder of such spring structure by a matrix material forming a unitary structure.

12. The elongated unitary composite spring structure of claim 11 including at least two such external plies helically wound in opposite directional relationship to each other between longitudinal ends of the spring structure.

13. The elongated unitary composite spring structure of claim 1 in which the non-woven fibers of the neutral axis portion, centrally located core portion, and the peripheral portion comprise glass fibers.

14. The elongated unitary composite spring structure of claim 13 in which such glass fibers have a maximum diameter of about 0.001 inch.

15. The elongated unitary composite spring structure of claim 13 in which such glass fibers comprise over 50% by weight of such elongated spring.

16. The elongated unitary composite spring structure of claim 1 in which the matrix material comprises a polymer such as epoxy resin.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,968,958 Dated July 13, 1976

Inventor(s) Paul V. Huchette and Homer H. Hall, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 4, after "division" delete the comma (,);

line 5, after "Pat." delete "Ser.".

Column 3, line 38, "on" should read --in--.

Column 6, lines 66 and 67, "appoximately" should read --approximately--.

Column 10, line 20, "netural" should read --neutral--.

Column 11, line 23, after the word "in", delete "the".

Signed and Sealed this

Twenty-sixth Day of October 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

US005816867A

United States Patent [19]

Davidsz et al.

[11] **Patent Number: 5,816,867**

[45] **Date of Patent: Oct. 6, 1998**

[54] **CURVED WIRE SPRING CLAMP WITH OPTIMIZED BENDING STRESS DISTRIBUTION**

[75] Inventors: **Mark E. Davidsz**, Milwaukee; **Jeffrey R. Annis**, Waukesha, both of Wis.

[73] Assignee: **Allen Bradley Company, LLC**, Milwaukee, Wis.

[21] Appl. No.: **701,602**

[22] Filed: **Aug. 22, 1996**

[51] **Int. Cl.**^{6} **H01R 4/48**

[52] **U.S. Cl.** **439/828**; 439/835

[58] **Field of Search** 439/716, 723, 439/721, 724, 789, 796, 439, 441, 828, 835, 838

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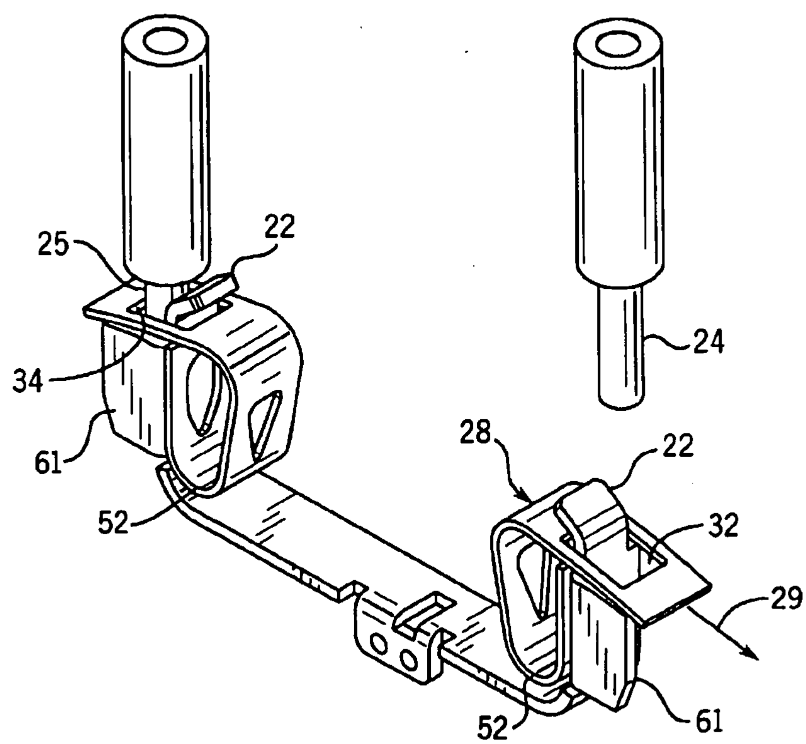
[57] **ABSTRACT**

A curved wire spring clamp which distributes bending stresses linearly based on the distance from the point of load application while maintaining torsional integrity. Bending stresses are distributed by providing apertures which change the effective width of the spring along its length. In the preferred embodiment the apertures approximate a triangular cantilever and are centrally placed along each leg portion near a constrained curved portion of the spring to change the spring's bending characteristics and distribute the bending stress more evenly throughout the length of the spring thereby reducing the peak bending stress level as compared with an equivalent spring design without apertures.

A loop shaped flat spring, consisting of curved portions and nearly straight portions with a decreasing effective width to the point of load application provides a more efficient design than a similarly shaped spring of constant width which reduces the bending stress at the constrained portions by distributing the bending stress throughout the straight portions.

16 Claims, 2 Drawing Sheets



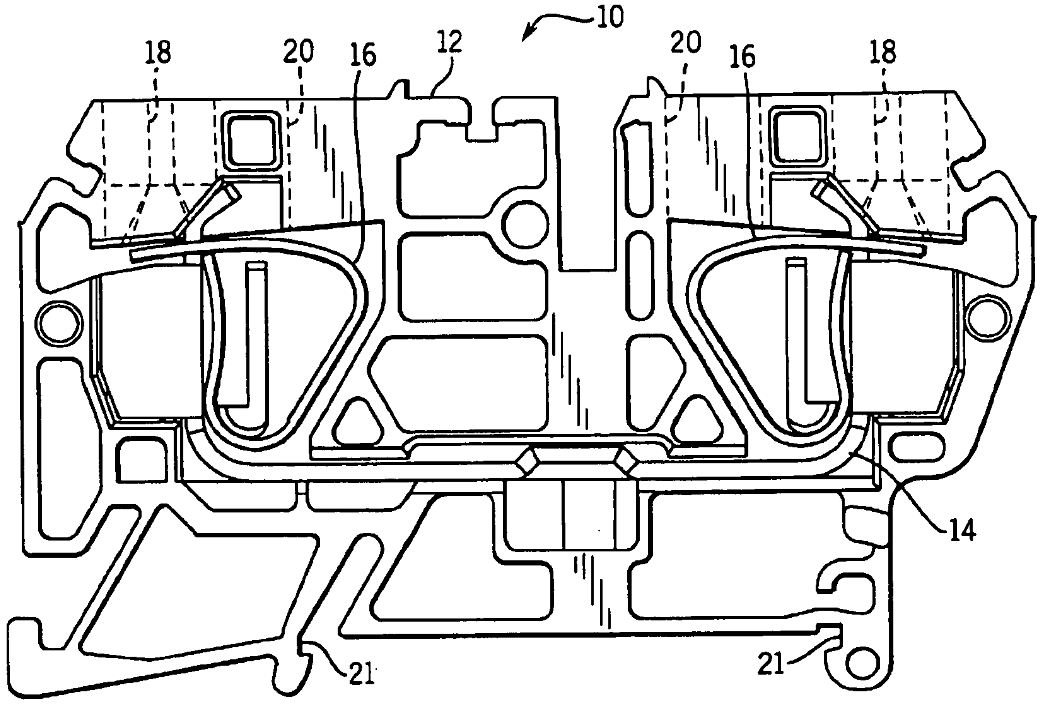


FIG. 1

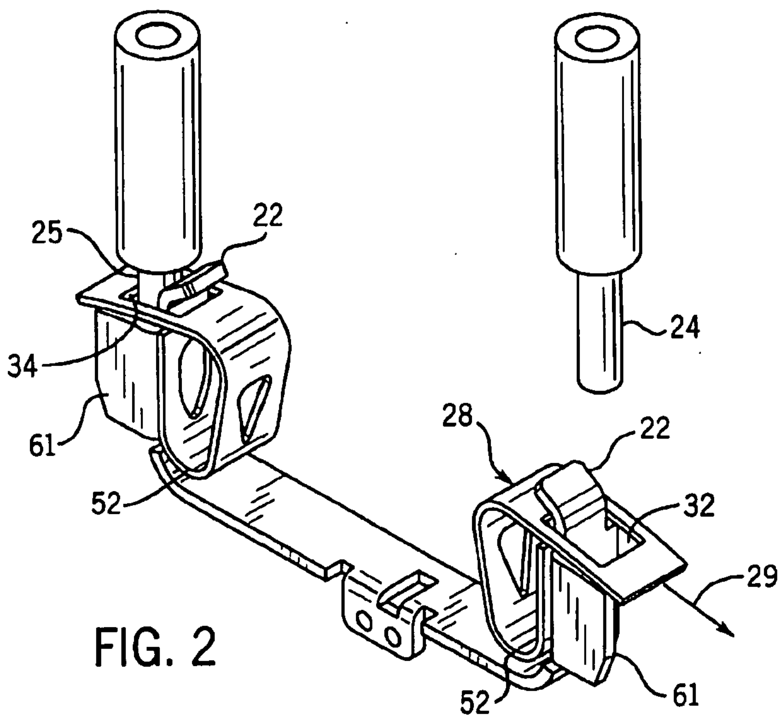


FIG. 2

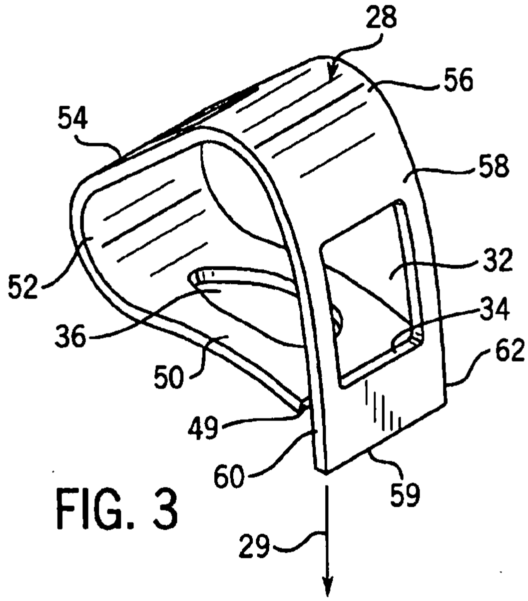


FIG. 3

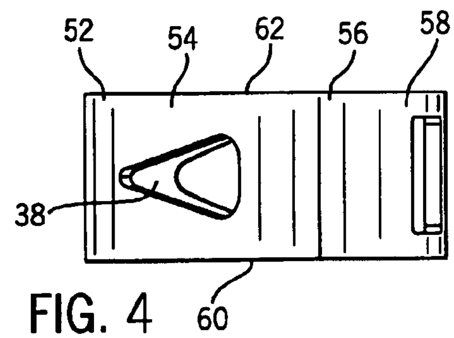


FIG. 4

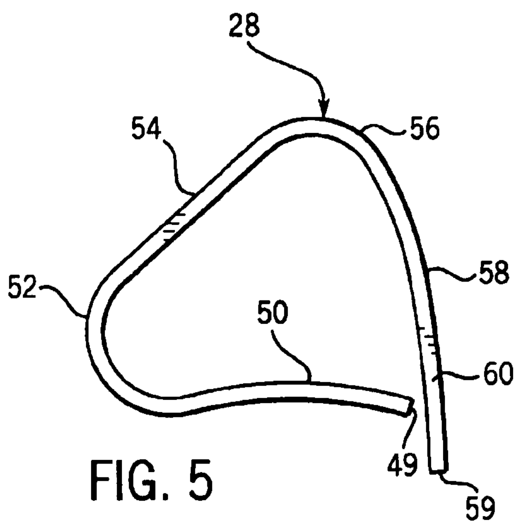


FIG. 5

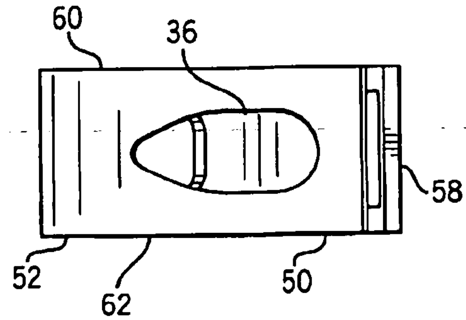


FIG. 6

CURVED WIRE SPRING CLAMP WITH OPTIMIZED BENDING STRESS DISTRIBUTION

FIELD OF INVENTION

This invention relates generally to an electrical terminal device and, more particularly, it relates to a curved wire spring clamp with optimized bending stress distribution.

BACKGROUND OF THE INVENTION

Some electrical wiring applications permit the use of screwless terminal blocks for quick and easy electrical connections. In general, a screwless terminal block incorporates a bus bar and clamping springs which have a constant width and thickness and sustain a high degree of stress in their constrained curved portions as compared with the straighter portions when flexed. As a result, in use, the higher stresses increase the likelihood of stress relaxation or premature failure from fatigue. Additionally, exceeding maximum stresses can result in permanent deformation such that the spring's shape and spring rate are undesirably changed.

It is possible to reinforce the curved portions by increasing the thickness along only the constrained portions, however such a spring is not easily manufacturable. Furthermore, increasing the entire spring's thickness alone is not an efficient use of raw materials and may undesirably increase the force required to actuate the spring and its cost.

Accordingly, there is a present need for a curved spring with optimized bending stress distribution in order to extend the spring's useful life by preventing the stresses from exceeding a maximum specified stress along the entire length of the spring, especially in the constrained portions. More specifically, there is a need for an efficient spring design which uniformly distributes bending stresses throughout the spring's length which, in turn, reduces stress relaxation, maximizes wire clamp loads, reduces overall spring size, and aids in increasing a spring's maximum working range.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a curved wire spring clamp which distributes bending stresses in a manner which decreases the stress upon a constrained curved region while maintaining torsional integrity. In particular, bending stresses are distributed by providing apertures which change the effective width of the spring along its length. In the preferred embodiment the apertures approximate a triangular cantilever and are centrally located along select leg portions of the spring near a constrained curved portion thereby changing the spring's bending characteristics and correspondingly distributing the bending stress more evenly throughout the length of the spring.

Typically, tapering the thickness of a section to obtain a nearly constant bending stress in a long thin spring material is difficult to achieve and not very manufacturable. However, the approach of varying the spring's effective width via an aperture as disclosed in the present invention is easily achieved using conventional stamping tools and dies.

A loop shaped flat spring, consisting of at least one curved portion and nearly straight portions with a decreasing effective width proximal the curved portion provides a more efficient design than a similarly shaped spring of constant width. Moreover, the provision of stress relieving apertures

decreases the effective spring width to approximate a triangular cantilever such that bending stresses are distributed throughout the leg portions, and correspondingly reduced in the constrained curved region.

It is therefore an object of the present invention to provide a curved wire spring clamp in which bending stresses are distributed more uniformly along the spring's entire length and not concentrated only at the curved region.

It is a further object of the present invention to provide a curved wire spring clamp wherein bending stresses are reduced proximal the constrained curved region.

It is yet another object of the present invention to provide a longer life curved wire spring clamp.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a curved spring clamp integrated within a molded plastic terminal block housing in accordance with the preferred embodiment of the present invention.

FIG. 2 is a perspective view of a curved spring clamp mounted on a current bar in accordance with the preferred embodiment of the present invention.

FIG. 3 is a perspective view of a spring clamp in accordance with the preferred embodiment of the present invention.

FIG. 4 is a top view of a spring clamp in accordance with the preferred embodiment of the present invention.

FIG. 5 is a front view of the spring clamp in accordance with the preferred embodiment of the present invention.

FIG. 6 is a bottom view of the spring clamp in accordance with the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1 there is shown an electrical terminal block **10** which incorporates the improved spring clamp of the present invention. In general, screwless terminal block **10** comprises a molded plastic housing **12**, a copper alloy current bar **14** and spring clamps **16**. As shown, both the spring clamps **16** and current bar **14** are fitted within housing **12**. The housing **12** also defines wire raceways or conductor pathways **18** and channels **20** and slots **21** for connecting the terminal block **10** to a mounting rail (not shown).

FIG. 2 depicts the arrangement of spring clamps **16** and current bar **14** in the preferred embodiment. In particular, wire retaining apertures **32** in each spring clamp **16** are fitted over the tangs **22** at the ends of current bar **14** such that the springs, by their own spring force, maintain engagement with the current bar. Thereafter, the entire current bar **14** and spring assembly is fitted within housing **12** as shown in FIG. 1.

In use, a screwdriver or similar implement (not shown) is inserted within channel **20** defined by housing **12** where it is guided along a path extending between the housing and the spring clamp **16**. In this manner a force is exerted on the spring **16** in the direction indicated by arrow **28**. As a result, the spring **16** bends about its curved portion **52** causing the wire retaining aperture **32** to translate in a direction **29** from its original position inside the current bar tang **22** to the outside of the current bar tang. Aperture **32** is then aligned with the wire raceway **18** defined by the housing **12** and the wire **24** may be fully inserted therein. After proper insertion of the wire **24**, the screwdriver or similar implement is

removed from the channel 20 thereby removing the applied force along direction 28 causing the spring clamp 16 to try to return to its original position, thus clamping the wire. In the clamping position, the inner wall 34 (shown in FIG. 3) of the wire retaining aperture 32 engages the wire 24 against the current bar tang 22 and outer surface of current bar 14. Wire 24 is further confined with the housing 12 by a flange 61 defined by the current bar 14 as depicted in FIGS. 1 and 2. In a similar manner a second wire 25 may be inserted within the opposing wire raceway 18 to form an electric circuit from wire 24 along the current bar 14 to the opposing current bar tang 22 and wire 25.

With respect to FIGS. 3–6 there is shown the curved spring clamp 16 of the present invention. As shown in FIG. 5, clamp 16 is generally loop shaped. Starting from a first end 49 the spring 16 is comprised of a bottom leg portion 50, a first curved portion 52, a top leg portion 54, a second curved portion 56 and a third leg portion 58 which defines a second spring end 59.

The clamping springs 16 may be manufactured by stamping a rectangular shape from a flat strip of metal. Similarly, apertures 36 and 38 and the wire retaining aperture 32 are stamped into the flat rectangular piece. Thereafter, the flat shape is permanently deformed to form the first curved portion 52 and the second curved portion 56 to form the spring clamp 16. In the preferred embodiment, the curved spring 16 has a constant width from a first edge 60 to a second edge 62 although the effective width varies as discussed below. When assembled on the current bar 14 and placed in housing 12 the first curved portion 52 becomes constrained.

As discussed above, application of a load in the direction of arrow 28 normally causes increased stress at the constrained portion 52. However, in the preferred embodiment shown apertures 36 and 38 are stamped in the spring 16 to decrease the effective width of the spring along the portions 50 and 54, respectively, proximal the first curved portion 52. As shown, the width of the apertures 36 and 38 are smallest proximal curved portion 52 and increase in size along the length of leg portions 50 and 54, respectively. In this manner the effective width along the leg portion 50 and 54 is decreased along a path away from the first curved portion 52. As a result the rigidness of the leg portions 50 and 54 decreases along the path away from curved portion 52. Conversely, the flexibility of the leg portions 50 and 54 is increased along the path away from first curved portion 52. A similar result would occur if the edges 60 and 62 along the leg portions 50 and 54 were increasingly tapered along the path heading away from the first curved portion 52. However, tapering edges 60 and 62 would leave a narrow width of spring that is more susceptible to fatigue from torsional forces, which may be applied to the spring 16 in use.

In the preferred embodiment, apertures 36 and 38 approximate a triangular cantilever in shape. More specifically, apertures 36 and 38 decrease the effective width of the leg portions 50 and 54, respectively, which causes the spring rate to decrease over the length of the spring. However, the spring rate is restored to that of a similar spring without apertures 36 and 38 by slightly increasing the spring thickness over the entire length of the spring. Moreover, since the spring rate varies directly with the third power of thickness and stress varies inversely with the second power of thickness, a lower stressed spring with an equivalent spring rate is achieved by slightly increasing the thickness when the apertures 36 and 38 are incorporated in the spring 16.

With reference to FIG. 3 a perspective view of spring clamp 16 shows the position of aperture 32 when the spring is in its free state and not mounted on current bar 14. As shown, the inner wall 34 does not extend beyond the first end 49 of the spring. Additionally, aperture 32 is preferably rectangular in shape in order to facilitate ease of mounting on the current bar tang 22.

With reference to FIG. 4 aperture 38 is generally triangular in shape. As discussed above, the aperture 38 decreases the effective width of the spring although the distance between edges 60 and 62 may remain relatively constant. Also, the aperture 38 is preferably located such that a corner of the triangular shape is centrally placed between the edges 60 and 62 at a point where the first curved region 52 meets with the second leg 54. As such, the effective width of the leg portion 54 is decreased along the path from the first curved region 52 to the second curved region 56. As a result, the flexiblity of leg portion 54 increases which decreases the bending stress on first curved region 52 providing a more uniform stress distribution along leg portion 54.

With respect to FIG. 5 there is shown a front view of the spring 16. As shown, the legs 50, 54 and 58 are either slightly curved or straight, so that the curvature of leg portions 50, 54 and 58 is less than either of the curved regions 52 or 56. When leg portion 50 is curved and the spring 16 is installed the leg 50 does not make contact with the current bar 14 along its entire length. Rather, the leg portion 50 contacts the current bar 14 near its first end 49 and the area where the first leg portion 50 meets the first curved portion 52 until flexed.

With respect to FIG. 6 there is shown a bottom view of the spring 16. Aperture 36 is generally tear drop shaped and slightly larger in area than aperture 38. In the preferred embodiment the apex of the tear drop is located equidistant from the edges 60 and 62 and proximal the location where the leg 50 and curved region 52 meet. In this manner the effective width of leg portion 50 is decreased along the path from the curved region 52 to the first end 49 although the actual width between edges 60 and 62 remains constant. As a result, the decreased effective width increases the flexiblity of leg portion 50 which correspondingly decreases the bending stress on first curved region 52 providing a more uniform stress distribution along leg portion 50.

While a particular embodiment of the present invention has been shown and described, it should be clear that changes and modifications may be made to such embodiment without departing from the true scope and spirit of the invention. For example, apertures 36 and 38 are shown to generally approximate a triangular cantilever, however other shape apertures may be employed having a similar effect. It is intended that the appended claims cover all such changes and modifications and others not specifically mentioned herein.

What is claimed is:

1. A spring clamp for use in screwless terminal block comprising a housing and a current bar, said spring comprising:

a first leg portion having a first end and defining a first stress relieving aperture;

a first curved portion contiguous with said first leg portion;

a second leg portion contiguous with said first curved portion, said second leg portion defining a second stress relieving aperture;

a second curved portion contiguous with said second leg portion;

a third leg portion contiguous with said second curved portion, said third leg portion defining a third aperture;

wherein said first leg portion, said first curved portion, said second leg portion, said second curved portion and said third leg portion generally define a loop shape.

2. The spring clamp as set forth in claim 1 wherein said third aperture is sized to accept a portion of said current bar and when accepted said first leg portion and said third aperture releasably engage said current bar.

3. The spring clamp as set forth in claim 1 wherein said first leg defines an arc having a radius of curvature greater than a radius of curvature of either said first or second curved portions such that said first leg engages said current bar along said first end and a point where said first leg and said first curved portion meet.

4. The spring clamp as set forth in claim 1 wherein said first aperture is generally triangular in shape.

5. The spring clamp as set forth in claim 1 wherein said second aperture is generally triangular in shape.

6. The spring clamp as set forth in claim 4 wherein said second aperture is generally triangular in shape.

7. The spring clamp as set forth in claim 1 wherein said first aperture is tear drop shaped.

8. A curved spring for use in a screwless terminal block comprising a housing and a current bar, said spring comprising:

a rectangular piece of metal defining a length between a first end and a second end, a width and a thickness, said thickness being substantially less than said length or width, said rectangular shape permanently deformed along said length in at least two areas between said first and second ends such that said piece of metal is loop shaped, said rectangular piece of metal further defining at least one stress relieving aperture and a wire retaining aperture, said at least one stress relieving aperture located proximal one of said at least two areas nearest said first end and said wire retaining aperture located proximal said second end.

9. The spring as set forth in claim 8 wherein said wire retaining aperture is sized to accept a portion of said current bar and when accepted said first end and said wire retaining aperture releasably engage said current bar.

10. The spring clamp as set forth in claim 8 wherein said at least one stress relieving aperture is generally triangular in shape.

11. A curved spring clamp for use in a screwless block comprising a housing and a current bar, said spring comprising:

a first leg portion having a first end and defining a first stress relieving aperture, said first leg portion further defining a first arc having a first radius of curvature;

a first curved portion contiguous with said first leg portion, said first curved portion defining a second arc having a second radius of curvature;

a second leg portion contiguous with said first curved portion, said second leg portion defining a second stress relieving aperture;

a second curved portion contiguous with said second leg portion, said second curved portion defining a third arc having a third radius of curvature, said first radius of curvature being substantially greater than said second radius of curvature and said third arc;

a third leg portion contiguous with said second curved portion, said third leg portion defining a third aperture and a second end;

wherein said first leg portion, said first curved portion, said second leg portion, said second curved portion and said third leg portion generally define a loop shape between said first end and said second end.

12. A curved spring for use in a screwless terminal block comprising a housing and a current bar, said spring comprising:

a first leg portion defining a first end;

a first curved portion contiguous with said first leg portion;

a second leg portion contiguous with said first curved portion;

a second curved portion contiguous with said second leg portion;

a third leg portion contiguous with said second curved portion and defining a wire retaining aperture and a second spring end; and

a means for relieving bending stress in said first curved portion defined by at least one of said first leg portion, said first curved portion, said second leg portion;

wherein said first leg portion, said first curved portion, said second leg portion, said second curved portion and said third leg portion generally define a loop shape between said first end and said second end.

13. The spring as set forth in claim 12 wherein said wire retaining aperture is sized to accept a portion of said current bar and when accepted said first leg portion and said wire retaining aperture releasably engages said current bar.

14. The spring as set forth in claim 12 wherein said first leg defines an arc having a radius of curvature greater than a radius of curvature of either said first or second curved portions such that said first leg engages said current bar along said first end and a point where said first leg and said first curved portion meet.

15. The spring clamp as set forth in claim 12 wherein said means for relieving bending stress is generally triangular in shape.

16. The spring clamp as set forth in claim 12 wherein said means for relieving bending stress is generally a tear drop shape.

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